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PROCESSING THE DATA FROM THE OGO-III GEGENSCHNEID PHOTOMETRY EXPERIMENT

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GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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1. INTRODUCTION

OGO-B SPACECRAFT

The Gegenschein Photometry Experiment is one of 20 geophysical experiments aboard the OGO-B spacecraft. These experiments are intended to provide information for gaining a better understanding of the earth and earth-sun relationships.

OGO-B (Figure 1-1) was launched from the Atlantic Missile Range into an eccentric orbit of about 31 degrees inclination. The spacecraft has a nominal perigee of 150 nautical miles, a nominal apogee of 60,000 miles, and an orbit period of 48.5 hours. The orbit path traverses the Van Allen radiation belts twice each orbit; it allows the spacecraft to make geophysical measurements from regions near the earth to those in cis lunar space.

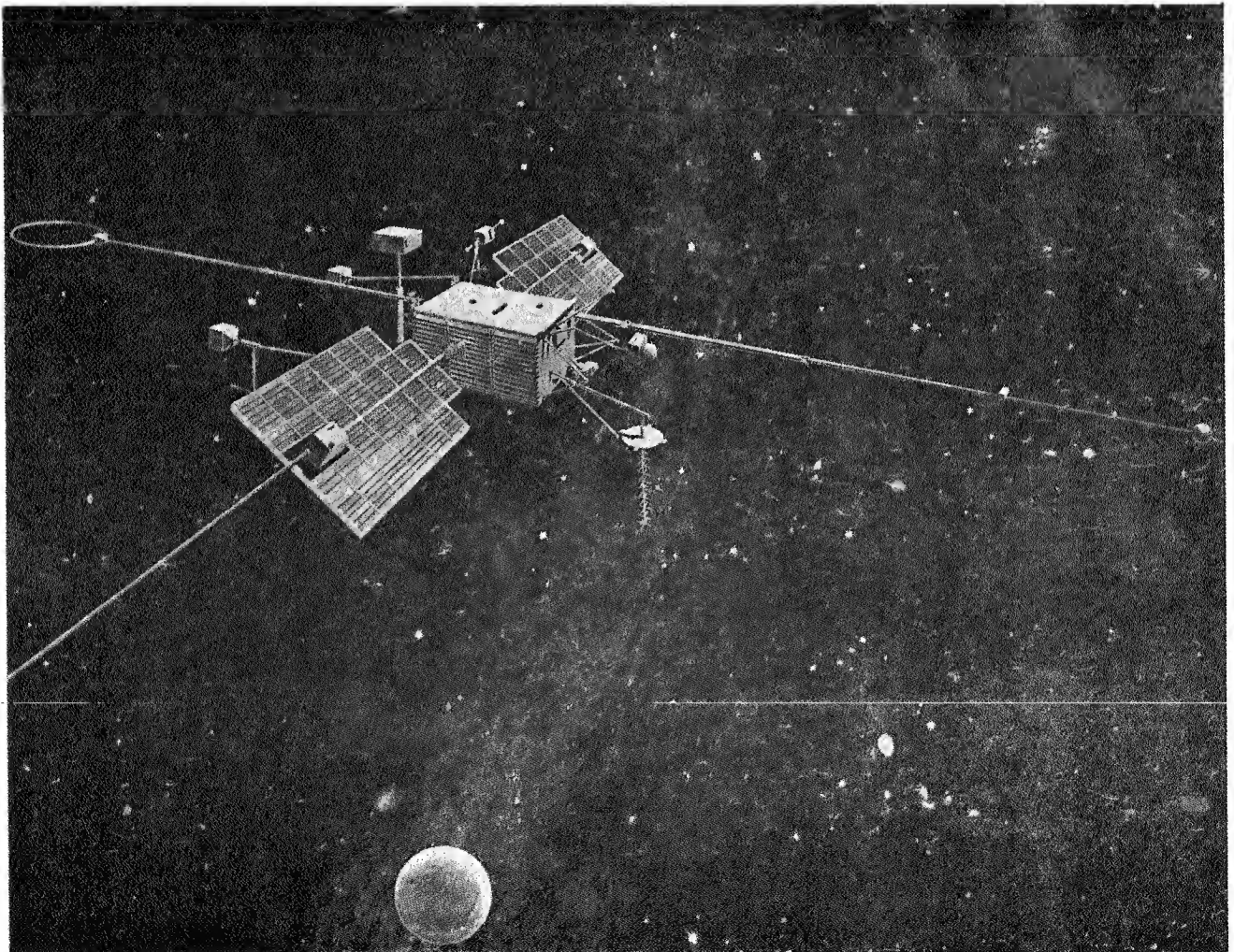


Figure 1-1. OGO-B Spacecraft

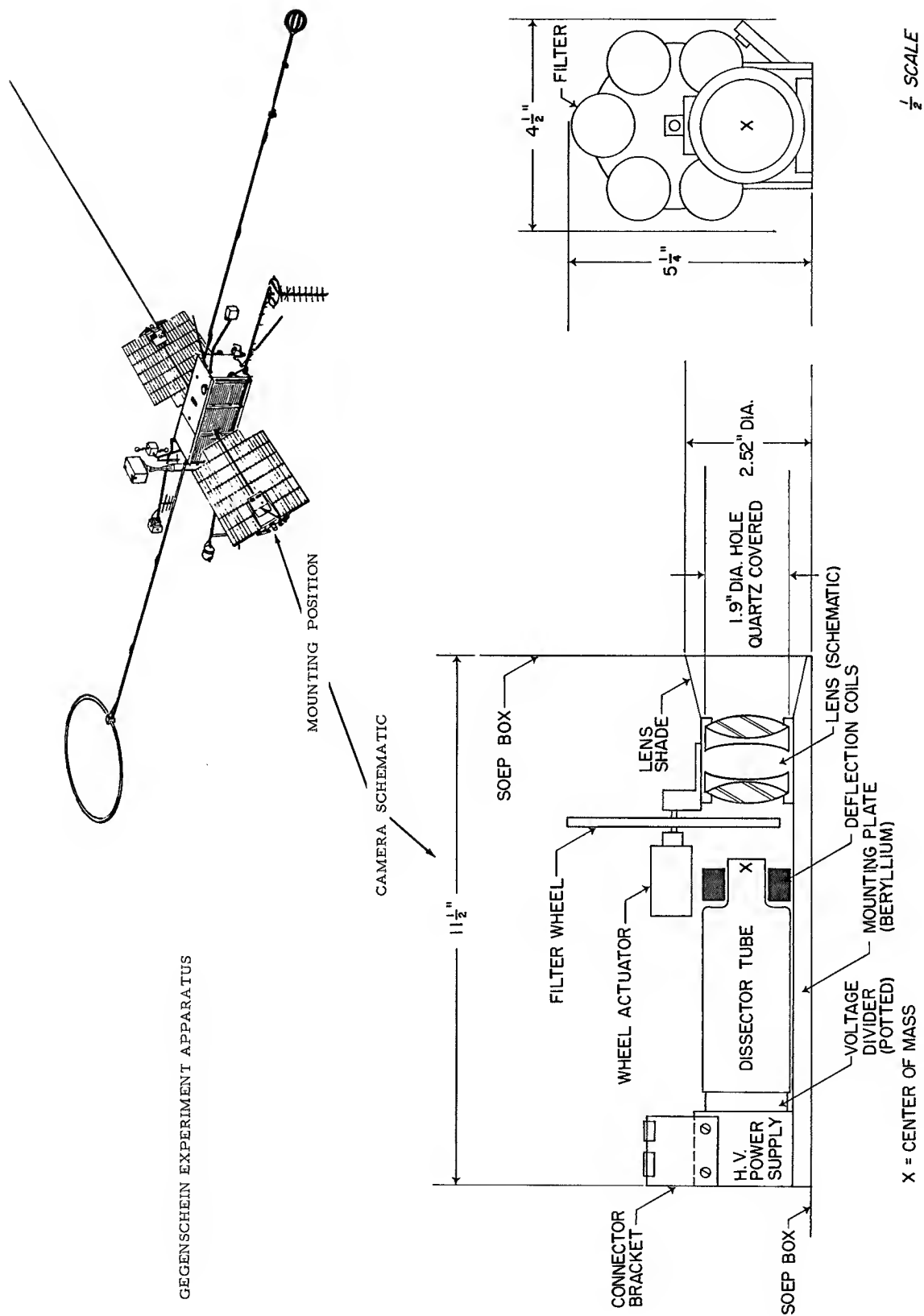


Figure 1-2. Gegenschein Experiment Apparatus

GEGENSCHHEIN PHOTOMETRY EXPERIMENT

The gegenschein (or counter glow) is a faint, elliptical patch of light that is visible in the night sky opposite the sun. It is thought to be a reflection of sunlight by meteoric matter in space whose origin is associated with the zodiacal light.

OBJECTIVES

The primary objective of the experiment is to determine the location of the gegenschein. Other objectives are to determine the following:

- . The shape and structure of the gegenschein, such as whether it is created by gas or dust.
- . Its spectral properties.
- . Variations in the shape, composition, and magnitude of the gegenschein.

APPARATUS

The experiment apparatus consists of a high photometric precision camera aimed in the anti-solar direction. As shown in Figure 1-2, the camera is part of a Solar Orbital Experiment Package (SOEP) mounted on one of the two solar arrays (SOEP 2) appended to the spacecraft body. The camera has a 2-inch (diameter) lens that projects an area of the sky 11° by 16° onto the face of an image dissector photomultiplier. Different spectral images are obtained through the use of a filter wheel containing five colored filters (the sixth filter wheel position contains a radioactive source at one corner and is used for calibration purposes).

DATA GENERATION

Each experiment cycle, the camera generates six images, one for each filter wheel position, plus the calibration. One set of pictures is generated approximately every 68 minutes at the 1K bit rate. Data is also generated at the 8K bit rate; at this rate, eight images are taken at each filter position for a total of 48 pictures per set.

Each image is in the form of a raster-type scan of an 11° by 16° sky area. It can be visualized as a rectangular array of 704 elements arranged in 22 lines of 32 elements each; an element depicts a sky area about $1/2^{\circ}$ by $1/2^{\circ}$. (See Figure 1-3.) The experiment apparatus transmits an intensity value for each element that can range from a value of 0 through 32,000.

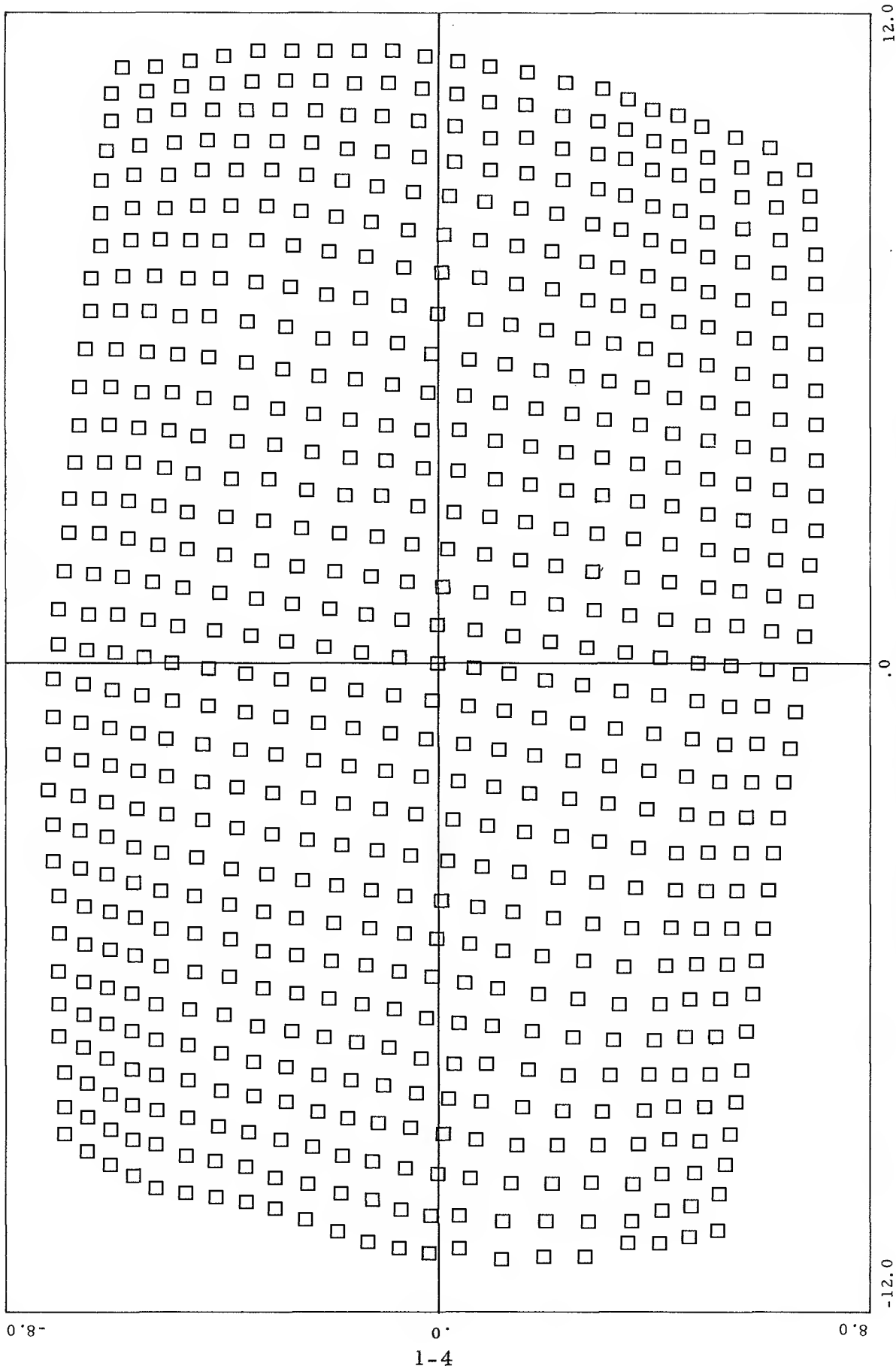


Figure 1-3. Display Raster Area (drawing from California Computer Products Plotter output).

DATA DISPLAY

Because the experiment can produce a large amount of data, it is necessary to depict this data in a form that facilitates fast and detailed evaluation. The ultimate display medium is a motion picture made from displays of the images on an SC 4020 microfilm plotter. It is also possible to obtain film for slide presentations from the SC 4020 as well as polaroid pictures from a special piece of equipment that displays individual pictures on a storage cathode ray tube. A sequence of pictures reproduced from 35mm. slide film is shown in Figure 1-4.

In addition to the filmed displays, the experiment data is printed in various formats that contain the intensity values by line for each element.

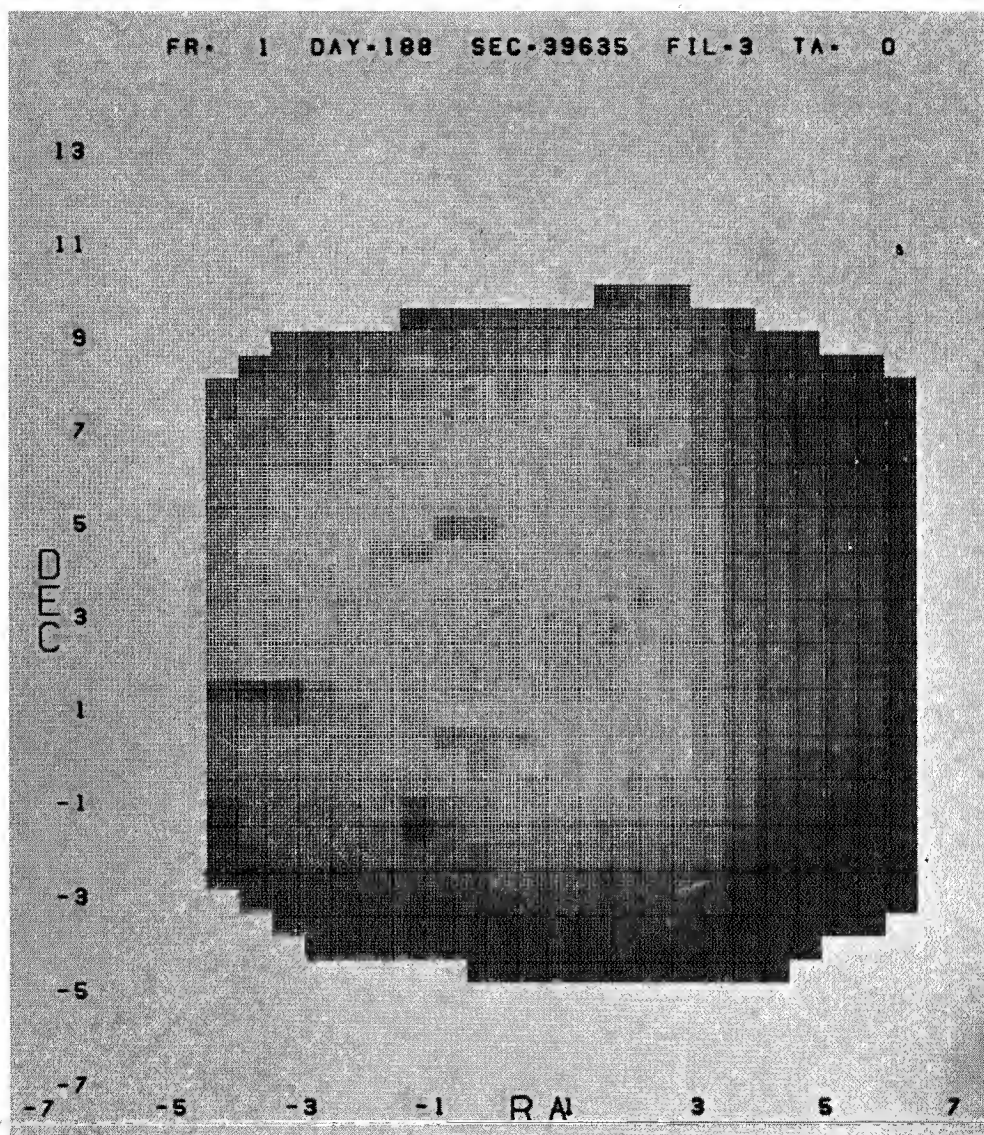


Figure 1-4. Display Example

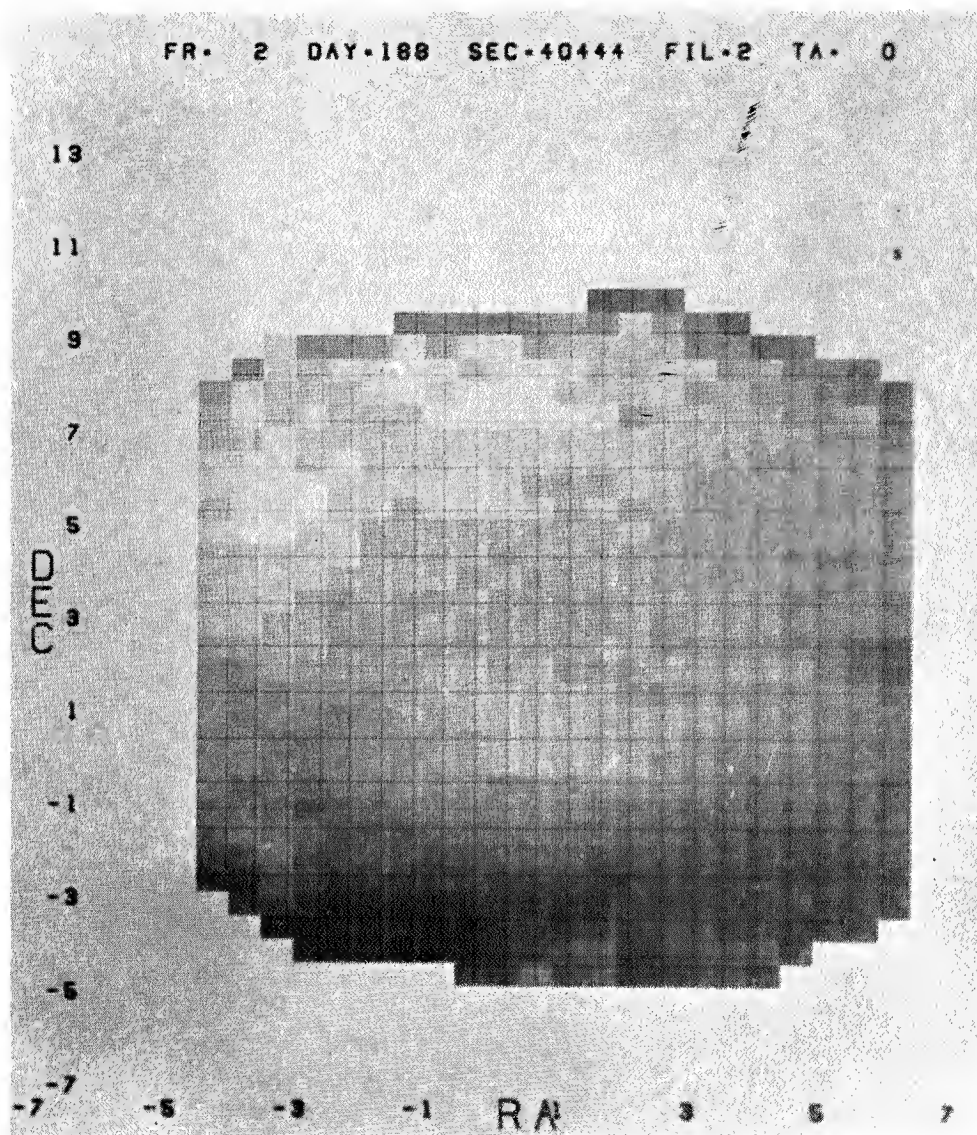


Figure 1-4. Display Example (continued)

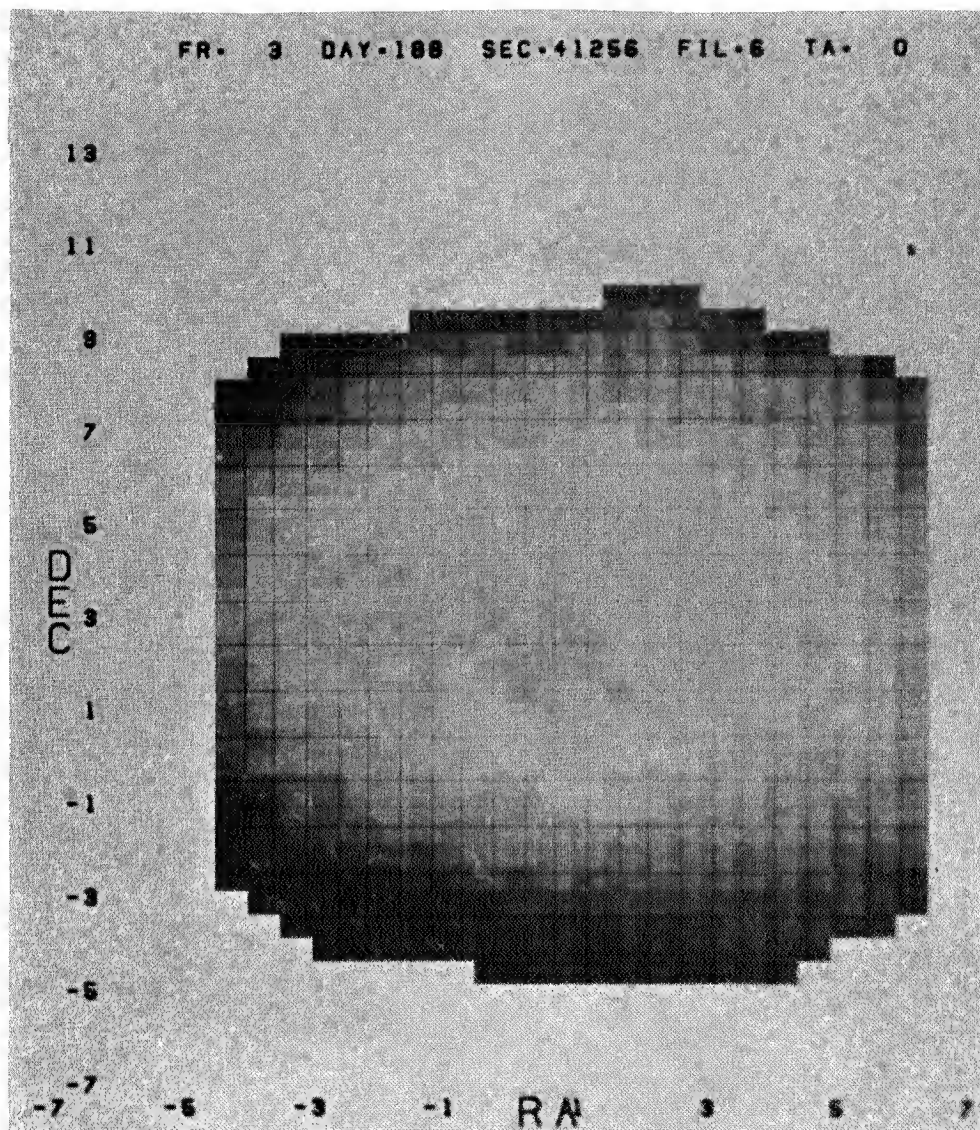


Figure 1-4. Display Example (continued)

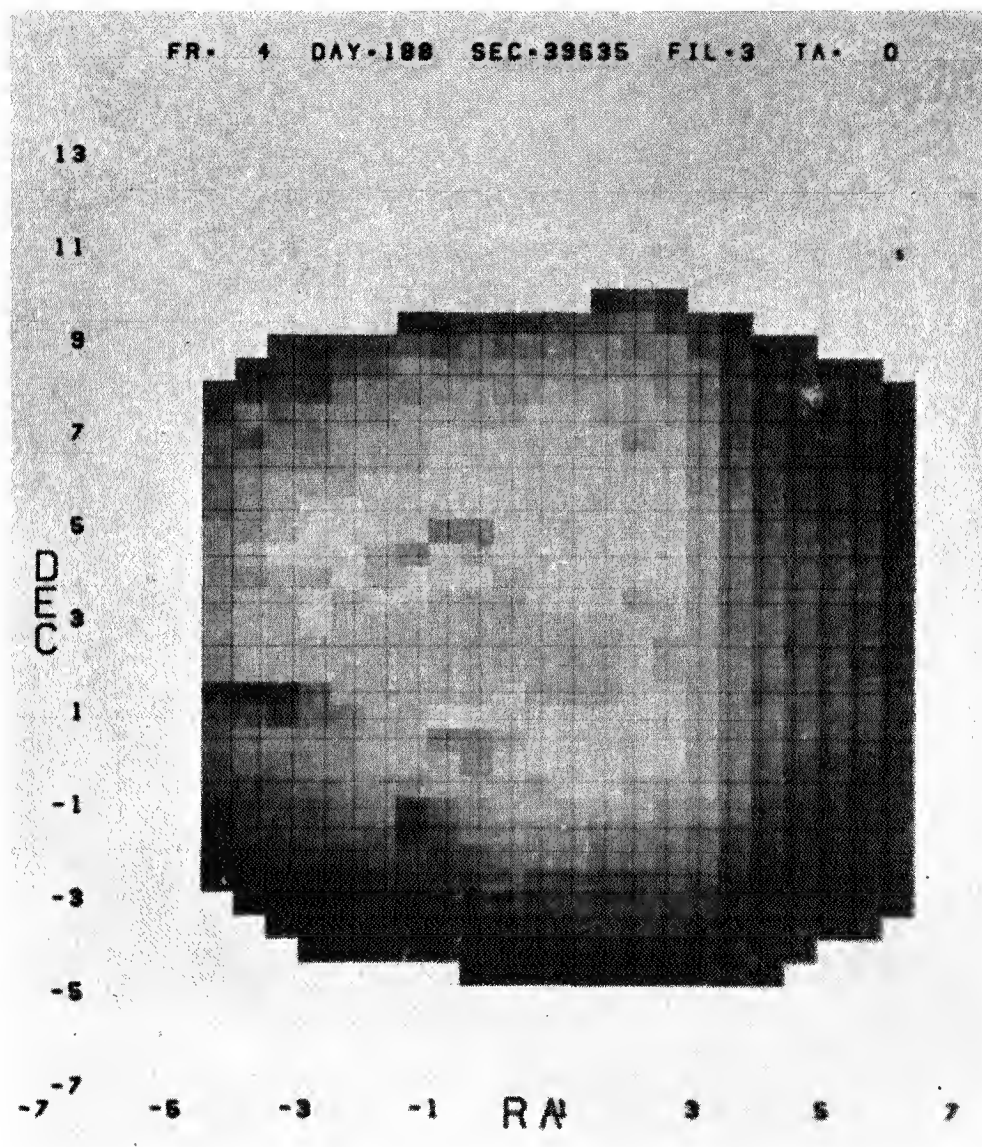


Figure 1-4. Display Example (continued)

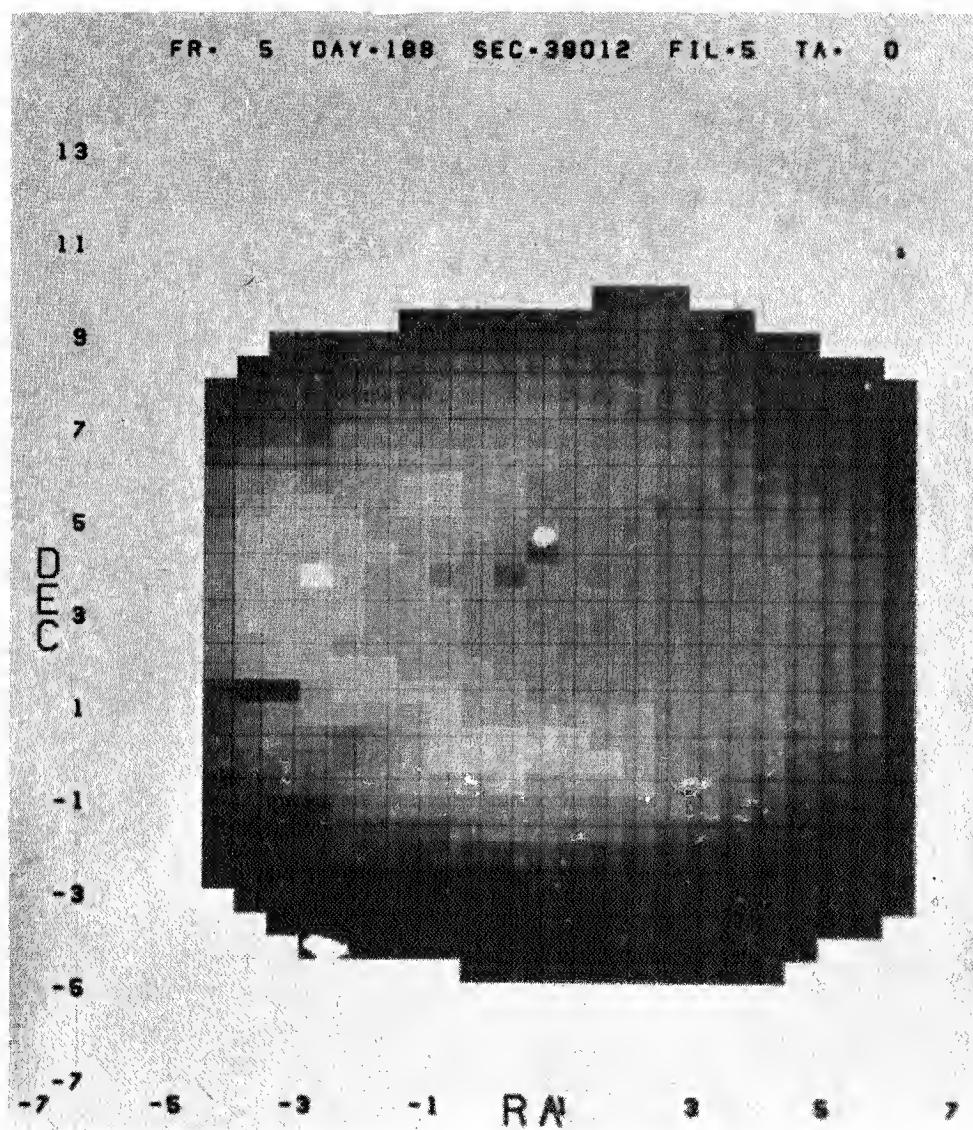


Figure 1-4. Display Example (continued)

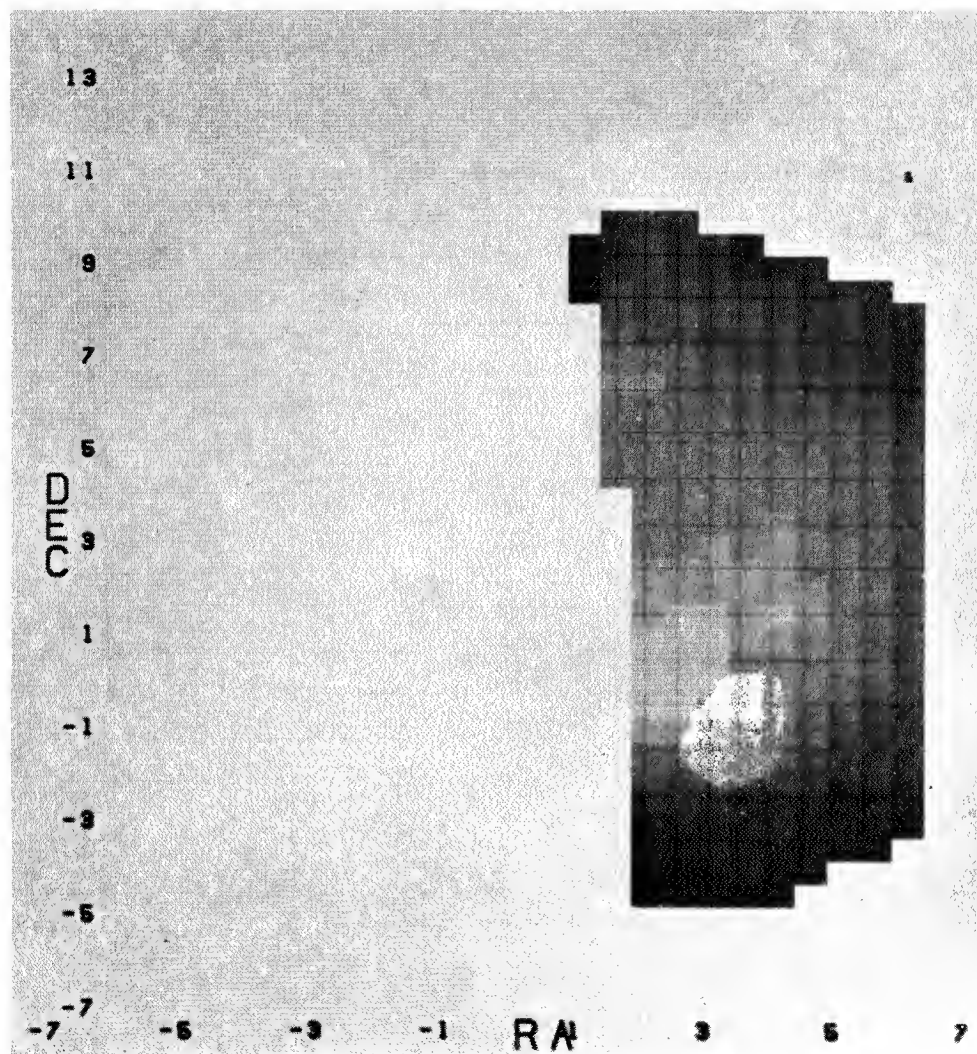


Figure 1-4. Display Example (continued)

DATA ANALYSIS SYSTEM

The Gegenschein Experiment Data Analysis System consists essentially of two Univac 1108 computer programs, a Processing Program and a Display Program. Figure 1-5 shows the relationships of these programs and their place in the entire OGO data processing system.

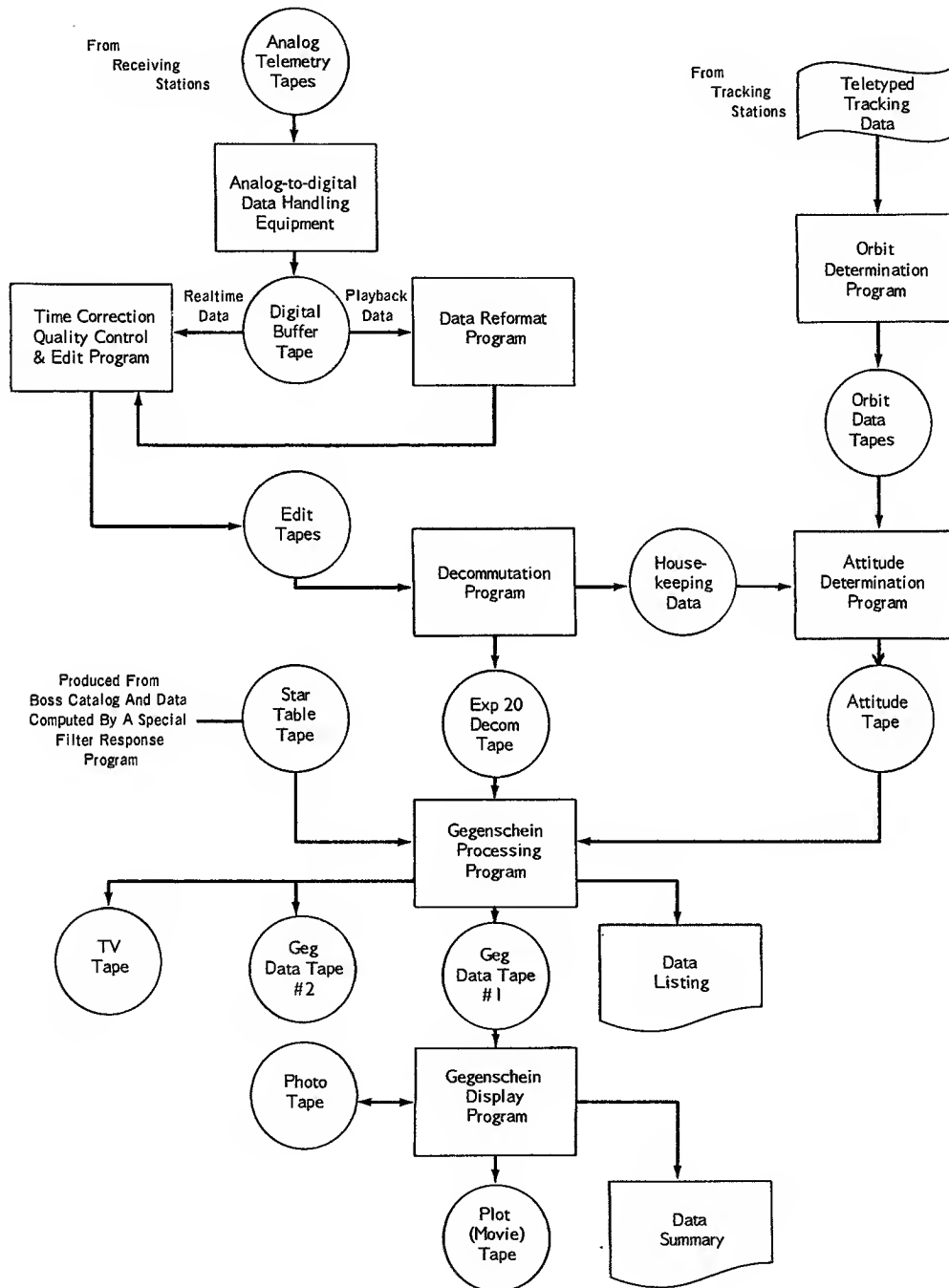


Figure 1-5. OGO Data Processing System Showing Gegenschein Experiment Programs

2. SYSTEM USAGE

GENERAL PROCEDURE

The Gegenschein Experiment Analysis System consists of two Univac 1108 programs as shown in Figure 2-1. They may be executed singly or as two consecutive jobs.

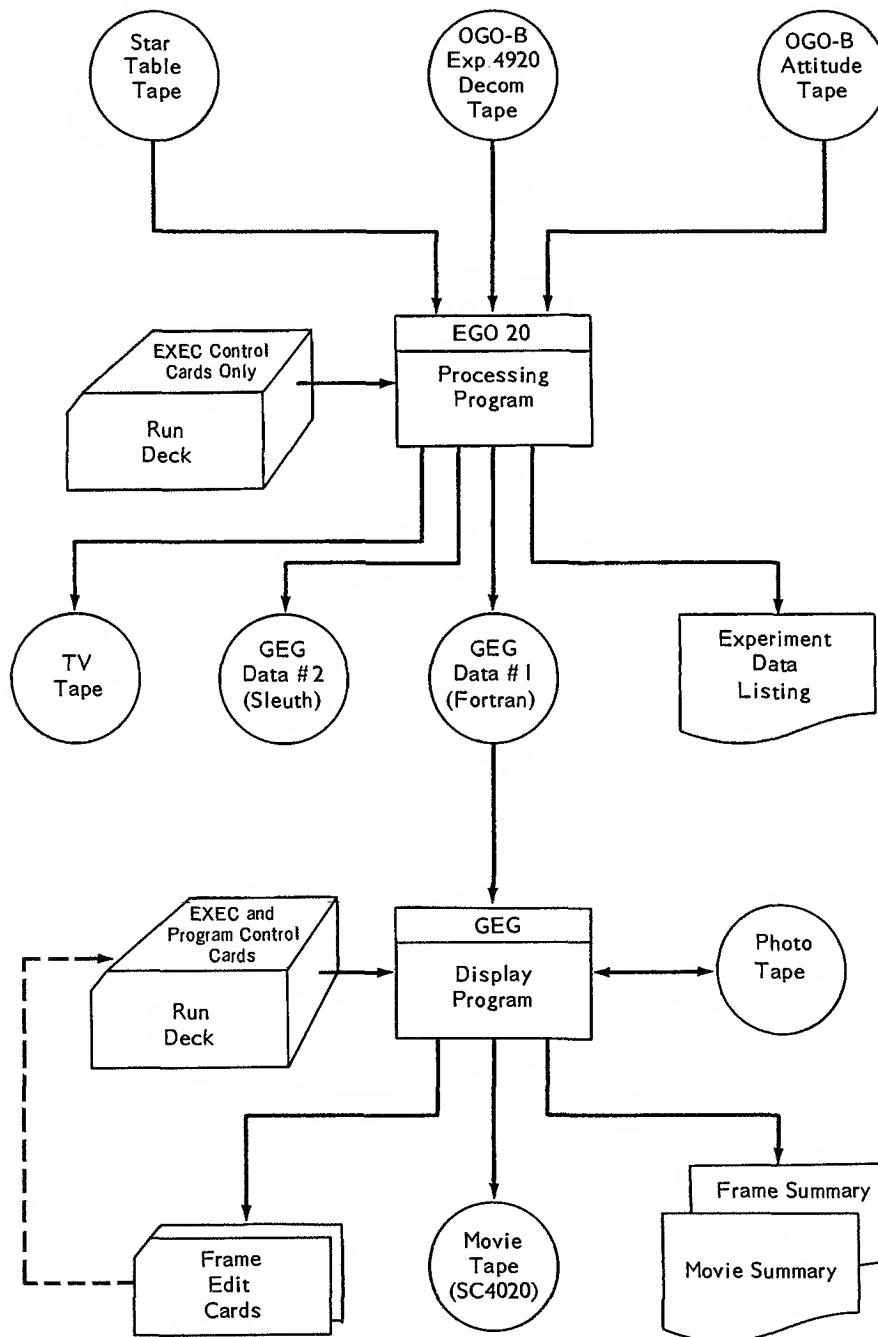


Figure 2-1. System Data Flow

PROCESSING PROGRAM

PROGRAM DESCRIPTION

The Processing Program correlates the decommutated experiment data and spacecraft attitude data, and re-creates the pictures taken by the camera. The results are output in the form of a printout of the picture values, a TV tape for oscilloscope display, and two gegenschein data tapes, one of which is input to the Display Program.

PROGRAM CONTROL

User control of the program is exercised entirely by console jump switches; no program control cards in the run deck are required (a Noise Parameter card may be included at user option; see option (6) in the discussion below).

USER OPTIONS

- (1) Decom File Skipping (Switches 1 to 4, 6 to 10, and 14): the program will skip up to 10 files on the Decom Tape before processing data. The switch number indicates the number of files to skip except for switch 14, which causes five files to be skipped.
- (2) Process One Decom File (Switch 15): processing may be restricted to one file on the Decom Tape by setting jump switch 15.
- (3) RA and DEC Corrections (Switch 5): when switch 5 is set, the program will apply corrections to the right ascension and declination values computed from the Attitude Tape.
- (4) Skip Attitude Tape (Switch 11): processing of spacecraft attitude data is bypassed when switch 11 is set.
- (5) Bypass Starry Background Processing (Switch 12): the program normally filters out the starry background from the experiment frames. When switch 12 is set, this processing is bypassed and the background stars are not eliminated from the displays.
- (6) Correct Raw Intensity Values (Switch 13): a user defined correction value may be subtracted from all raw intensity values by:
 - (a) Defining the correction value in a Noise Parameter Card (cols. 1-6, right-adjusted) in the run deck, and
 - (b) setting Switch 13.

RUN EXECUTION

Machine Requirements

Device	Yes	No	Amount/Number
Tape Drives	X		7
Card Reader	X		
Printer	X		
Punch		X	
Drum		X	
Disk		X	

Input-Output

	Description	Device
INPUT	Program Tape	Tape Z
	Table Tape	Tape I
	Decom Tape	Tape L
	Attitude Tape	Tape M
	Run Deck	Card Reader
OUTPUT	TV Tape	Tape P
	Gegenschein Data Tape #1 (Sleuth)	Tape Q
	Gegenschein Data Tape #2 (Fortran)	Tape N
	Data Listing	Printer

Tape Arrangement

	Description	Device	Op Label	Disposition
INPUT	Program	Z	EGO20	
	Exp. 20 Decom	L	DECOM	
	Exp. 20 Star Table	I	TABLE	
	OGO-B Attitude	M	ATTAPE	
OUTPUT	TV Tape	P	TVTAPE	For Oscilloscope Display
	Experiment Data #1	N	TAPE1	
	Experiment Data #2	Q	TAPE2	Input to Display Program as GEG tape.

Jump Switches

The following are jump switch options; no jump switches are required by the program.

Jump Switch	Position	Action
1-4 & 6-10	Set	Skip "n" files on the Decom Tape, where "n" is the switch number (see switches 14 and 15 below).
5	Set	Apply corrections to right ascension and declination values.
11	Set	Do not process Attitude Tape.
12	Set	Do not perform starry background processing.
13	Set	Read Noise Parameter Card (see run deck) and subtract parameter from raw intensity values.
14	Set	Skip 5 files on the Decom Tape.
15	Set	Process only one Decom File.

Run Deck Set-Up

▽ RUN (run name)

▽ MSG LOG NUMBER (number)

▽ ASG Z = EGO20

▽ ASG I = TABLE

▽ ASG L = DECOM

▽ ASG N = TAPE1

▽ ASG M = ATTAPE (not required if Jump Switch 11 is set)

▽ ASG Q = TAPE2

▽ ASG P = TVTAPE

▽ XQT CUR

TRW Z

ERS

IN Z

TRI Z

TOC (optional)

▽ XQT EGO20

Noise Parameter Card (optional - if present Jump Switch 13 must
be set)

▽ FIN

Messages

Message	Text
A	UNRECOVERABLE ERROR ON ASPECT TAPE
B	WRONG ASPECT TAPE
C	A LINE EXCEEDED 32 ELEMENTS, SKIPPED PICTURE
D	PICTURE EXCEEDS 22 LINES, SKIPPED
E	BAD DECOM TAPE - CANNOT READ
F	TROUBLE WRITING TV TAPE
H	FOUND EOF
I	TROUBLE WRITING ON TAPE2

Message	Appears On	Program Action			Operator Action
A	Typewriter	Jumps to MERR\$			None Required
B	Typewriter	Jumps to MERR\$			
C	Printer	Continues			
D	Printer	Continues			
E	Typewriter	Writes EOF on Q Rewinds Q, N, P, L, M Jumps to MEXIT\$			
F	Typewriter	Jumps to MERR\$			
H	Printer	Jump Key 15	off	Does next Decom File	
			on	EOF on N, P, Q Rewind N, P, Q, L, M Jumps to MEXIT\$	
I	Typewriter	Jumps to MERR\$			

DISPLAY PROGRAM

PROGRAM DESCRIPTION

This program generates a photo data tape from the gegenschein data tape produced by the Display Program, then produces an edited movie tape for use with the SC 4020 Microfilm Plotter (see Fig. 2-2). These functions are performed during the two major program processing phases, the preprocessing phase and the display phase.

In the preprocessing phase, one or more gegenschein tapes are introduced in time sequence to a filtering process where unrecognizable data frames are eliminated. All information contained in a valid frame is placed on the Photo Tape, which serves as a collection pool for the frame data. This tape will hold approximately 700 picture frame data sets; in later runs, additional sets may be added to the tape at user option.

Each data set constitutes a file on the tape; each frame is given a sequential number, which is also the file number. For each frame written on the Photo Tape, a Display Edit Card is punched with the frame number and a printout of the frame data is produced. At the option of the user, additional parameters may be punched into the cards to control frame editing during the display phase.

In the display phase, the data on the Photo Tape is converted to SC 4020 instructions for visual presentation under control of the Display Edit Cards produced in the preprocessing phase. The editing may compensate for wide ranging intensity levels or picture skewness (which can be determined by examination of the printout produced in the first phase).

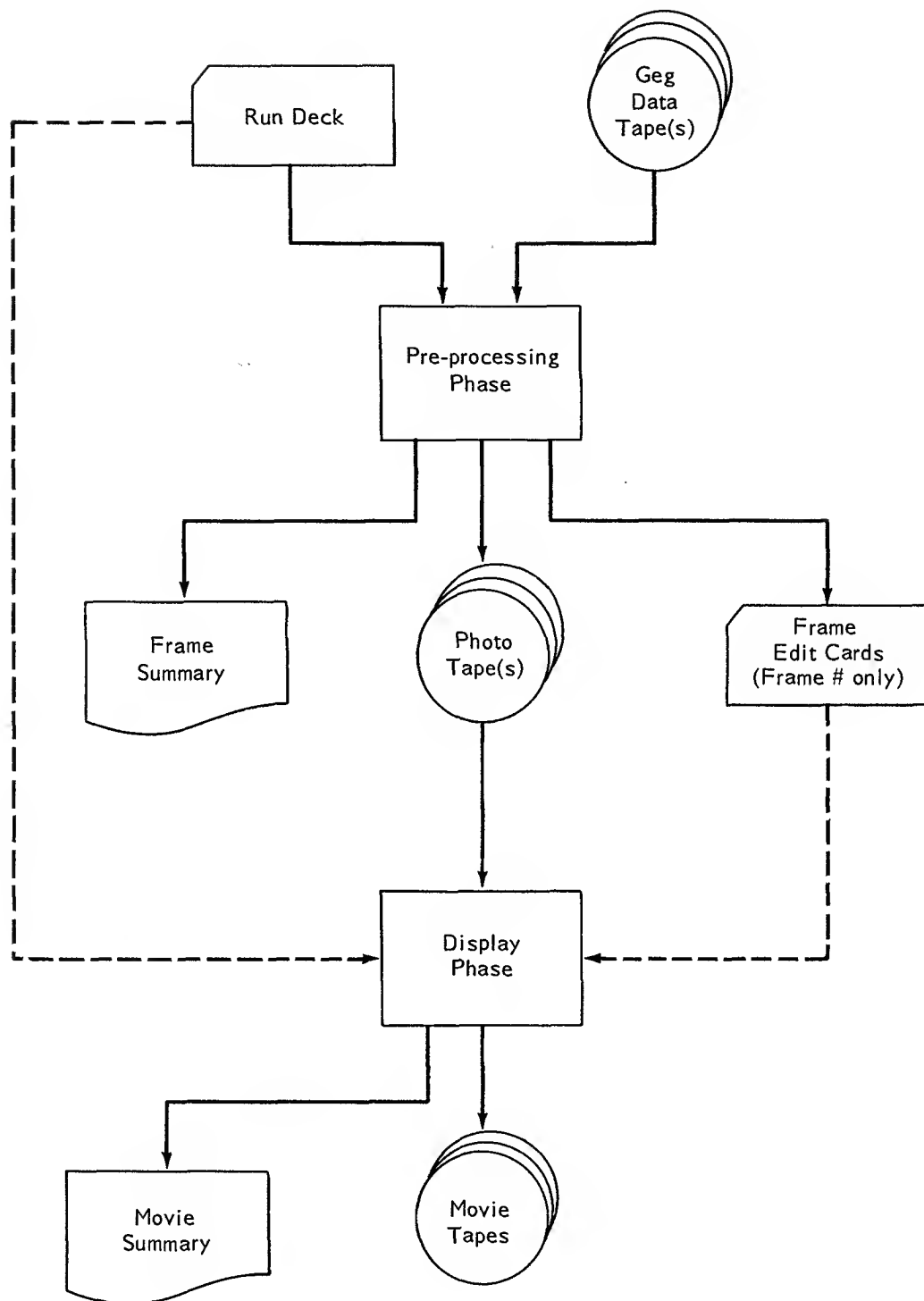


Figure 2-2. Display Program: Processing Phases and Data Flow

PROGRAM CONTROL

The program is controlled by the following control cards in the run deck (Figure 2-3):

- (1) Basic Input Cards: this set of six cards gives the user control over the operation of the program and the format and amounts of data produced for display. The sixth card is the Master Overlay Card, which controls the format of all frames produced during the run; Display Edit Cards may be used to change the master overlay information for specified frames.

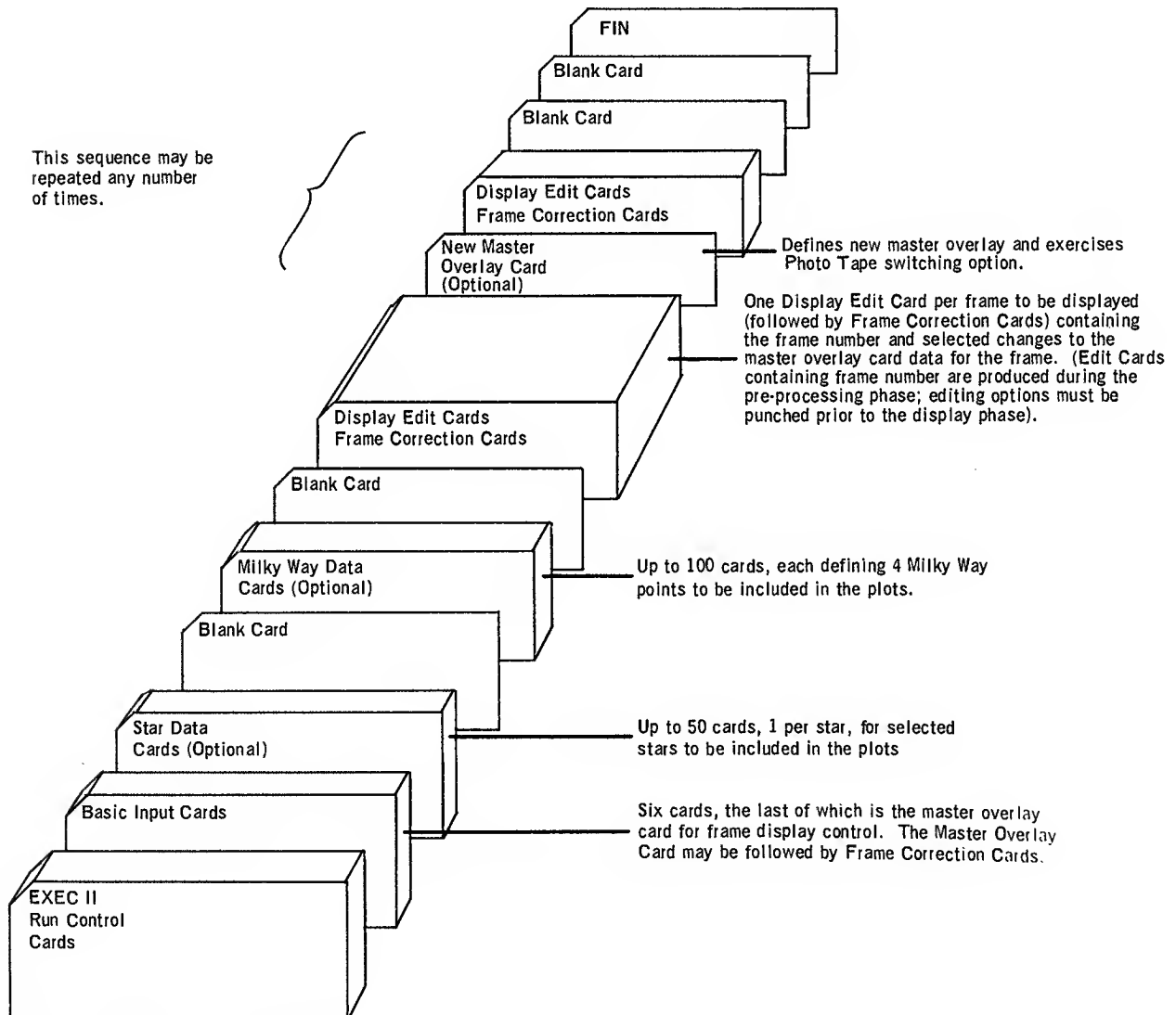


Figure 2-3. Display Program: Control Card Arrangement

- (2) Star Data Cards: these cards may be included at user option to cause selected stars to be included in all picture frames produced during the run.
- (3) Milky Way Data Cards: these cards may be included at user option to cause the milky way outline to be included in all frames produced during a run.
- (4) Display Edit Cards: these cards, one for each frame, allow the user to control the order of frame display and to specify editing corrections to the master overlay defined in the basic input.
- (5) Frame Correction Cards: these cards may be used to change the intensity levels of specified raster positions. When the change applies to all frames, the cards follow the Master Overlay Card; when the change applies to a particular frame, the cards follow the Display Edit Card for the frame.

USER OPTIONS

User options are exercised entirely by program control cards; no jump switch or other console options are provided.

- (1) Gegenschein Tape(s) Option (Basic Input Card #4 - Word 4): the user has the option to bypass the preprocessing phase (by indicating no gegenschein tapes) or to process any number of tapes. When the phase is bypassed, the Photo Tape is assumed to contain valid frames from a prior run, which are formatted and written onto the Plot Tape under control of the Master Overlay Card (Basic Input Card #6) and the Display Edit Cards.

When gegenschein tapes are present, the contents of each are processed and written onto the Photo Tape before the display phase is entered. However, the program will stop (run termination) at the beginning of the display phase if either of the following conditions exist:

- (a) A Photo Tape swap was made during preprocessing.
- (b) No Display Edit Cards are present.

- (2) Photo Tape File Skipping (Basic Input Card #4 - Word 5): when new frames are to be added to a valid Photo Tape (preprocessing phase), the user may define the number of tape files to be skipped before writing the new frames.
- (3) Star Plots (Star Data Cards): a maximum of 50 selected stars may be included in all frames produced during the run by defining the star positions and intensities in Star Data Cards.
- (4) Milky Way Plots (Milky Way Data Cards): a maximum of 400 points of the milky way may be included in all frames produced during the run by defining the point positions in the Milky Way Data Cards; the same intensity (a program constant) is used for all points defined.
- (5) Frame Format Control (Basic Input Cards): the basic input cards give the user a number of options for controlling frame formats for all frames produced during the run (individual frame formats may be changed by frame editing options as described below). These options include the following:
 - (a) The number of right ascension (RA) columns and declination (DEC) rows per frame (Basic Input Card #4).
 - (b) The usable SC 4020 area, with position and size of titles and labels (Basic Input Cards #1, #4, and #5).
 - (c) Degree height and width of the data raster and the density factor (Basic Input Cards #4 and #5).
 - (d) The maximum number of frames to be output to the Photo Tape (Basic Input Card #1).
 - (e) High and low intensity parameters for the experiment camera filters (Basic Input Cards #2 and #3).
- (6) Display Editing (Display Edit Cards): a number of options are available for controlling the format of individual frames. These are exercised by a combination of the Master Overlay Card (Basic Input Card #6) and the Display Edit Cards. The Master Overlay Card defines display values that can be changed from frame to frame by the user. The Display Edit Cards, one for each frame to be displayed, may be used to selectively preempt any master overlay value for the frame (the Display Edit Card format is essentially a duplicate of the Master Overlay Card format). The following rules pertain to use of the Display Edit Cards:

- (a) A frame is displayed only if a Display Edit Card containing the frame number (at a minimum) is present in the run deck.
- (b) Frames are displayed in Display Edit Card order.

For any frame, the following options may be exercised in the Display Edit Card:

- (a) The size of the picture can be contracted or expanded in both height and width.
 - (b) Intensity level slopes can be changed for interpolation purposes (e.g., light pictures made darker, etc.)
 - (c) Projection of the first "n" and last "m" rasters may be deleted.
 - (d) Two raster position corrections may be induced. One is a fine correction where rasters are positioned $1/2^\circ$ apart; the other is a coarse correction which causes only wild values to be repositioned.
 - (e) Frame averaging may be selected for data received at the 8K bit rate (8 pictures per filter wheel position) and 64K bit rate (8 pictures per filter wheel position). The user has the option to average in all pictures for a frame and obtain one average plot, or to plot a frame and also cause it to be averaged in with others. On plotted frames, a frame number of zero indicates the results of an averaged set of frames.
- (7) Intensity Correction Option (Frame Correction Cards): intensity corrections to individual rasters in all frames or a particular frame may be defined using a combination of data in the Master Overlay Card and Frame Correction Cards, or a combination of data in the Display Edit Cards and Frame Correction Cards.

The Frame Correction Cards contain the RA and DEC of the raster to be corrected. When the corrections apply to all frames generated during the run, the Frame Correction Cards follow the Master Overlay Card; the desired intensity levels are defined in words 6 and 7 of the Master Overlay Card.

When the corrections apply to a particular frame, the Frame Correction Cards follow the Display Edit Card for the frame; the desired intensity levels are defined in words 8 to 12 of the Display Edit Card.

In both cases, raw and/or corrected data may be corrected for intensity. When both types of corrections are present, the Frame Correction Cards for raw data must precede those for corrected data. The number of cards of each type must be specified in words 15 and 16 of the Master Overlay Card or the Display Edit Card as appropriate.

- (8) Restart Option: the user has the option to introduce new Master Overlay Cards and associated Display Edit Cards in the same run; a new Master Overlay Card supercedes the preceding one. A further option is provided to indicate continuation with the current Photo Tape or to pause for mounting of a new tape.

CONTROL CARD FORMATS

Basic Input Cards

The basic input consists of the following six cards:

- (1) Card #1: defines various parameters pertaining to the program and the run.
- (2) Card #2: defines the high and low intensity values for filters 1 through 4 for both raw and corrected experiment data.
- (3) Card #3: the same as Card 2 but for filters 5, 6, and 7.
- (4) Card #4 and #5: define various parameters for program and plot control.
- (5) Card #6: the Master Overlay Card for controlling display frame formats (changes in the master overlay may be specified for individual frames in Display Edit Cards).

Card #1 (Format: 16I5)

Word	Columns	Normal Value	Description
1	1-5	3	Gegenschein Data Tape assignment.
2	6-10	2	Photo Tape assignment.
3	11-15	1	Plot Tape assignment.
4	16-20	1	SC camera number.
5	21-25	10	Number of consecutive blank gegenschein data frames; signals end of data.
6	26-30	500	Maximum number of frames to be output to the Photo Tape.
7	31-35	412	Number of words in the Gegenschein Data Tape identification (ID) record.
8	36-40	704	Number of words per Gegenschein Data Tape data record.
9	41-45	9	Number of the ID record word containing the filter number.
10	46-50	50	Minimum allowable number of zero Right Ascension (RA) values (for filtering).
11	51-55	120	Minimum usable SC 4020 X border (upper left).
12	56-60	120	Minimum usable SC 4020 Y border (upper left).
13	61-65	960	Maximum usable SC 4020 X border (lower right).
14	66-70	960	Maximum usable SC 4020 Y border (lower right).
15	71-75	5	Number of Gegenschein Data Tape data records per ID record (data block).
16	76-80	16	Number of parameter words in this card (I5 format).

Card #2 (Format: 16I5)

Word	Columns	Description
1	1-5	Filter 1: low intensity for raw data.
2	6-10	Filter 1: high intensity for raw data.
3	11-15	Filter 1: low intensity for corrected data.
4	16-20	Filter 1: high intensity for corrected data.
5	21-25	Filter 2: low intensity for raw data.
6	26-30	Filter 2: high intensity for raw data.
7	31-35	Filter 2: low intensity for corrected data.
8	36-40	Filter 2: high intensity for corrected data.
9	41-45	Filter 3: low intensity for raw data.
10	46-50	Filter 3: high intensity for raw data.
11	51-55	Filter 3: low intensity for corrected data.
12	56-60	Filter 3: high intensity for corrected data.
13	61-65	Filter 4: low intensity for raw data.
14	66-70	Filter 4: high intensity for raw data.
15	71-75	Filter 4: low intensity for corrected data.
16	76-80	Filter 4: high intensity for corrected data.

Card #3 (Format: 12I5)

Word	Columns	Description
1	1-5	Filter 5: low intensity for raw data.
2	6-10	Filter 5: high intensity for raw data.
3	11-15	Filter 5: low intensity for corrected data.
4	16-20	Filter 5: high intensity for corrected data.
5	21-25	Filter 6: low intensity for raw data.
6	26-30	Filter 6: high intensity for raw data.
7	31-35	Filter 6: low intensity for corrected data.
8	36-40	Filter 6: high intensity for corrected data.
9	41-45	Filter 7: low intensity for raw data.
10	46-50	Filter 7: high intensity for raw data.
11	51-55	Filter 7: low intensity for corrected data.
12	56-60	Filter 7: high intensity for corrected data.

Card #4 (Format: 16I5)

Word	Columns	Normal Value	Description
1	1-5	608	Plot output buffer size (words).
2	6-10	22	Number of RA columns per frame.
3	11-15	32	Number of DEC rows per frame.
4	16-20	0 or n	Gegenschein Data Tape option: 0 = no Gegenschein Tape. n = number of Gegenschein Tapes to process.
5	21-25	n	Photo Tape file skip option: n = 0: photo tape is scratch. n \neq 0: skip n files and add frames from the Gegenschein Tape.
6	26-30	3	Density factor: number of SC 4020 plot rasters per plot point.
7	31-35	5	Degrees error times 10 before course correction is made.
8	36-40	20	Number of plot output buffers.
9	41-45	2000	Number of words, times 10^{-3} , per Plot Tape before tape swap.
10	46-50	0 or 1	1 = print 704 RA, DEC, and intensity values per frame.
11	51-55	0 or 1	1 = print Gegenschein Data Tape label record data for each frame.
12	56-60	0 to 4	Overplotting options: 0 = no overplot. 1 = overplot with box. 2 = overplot with O (alphabetic). 3 = overplot with zero. 4 = plotting dot.

Card #4: (continued)

Word	Columns	Normal Value	Description
13	61-65	0 or 1	1 = print elapsed compute time for a picture.
14	66-70		Not used.
15	71-75		Number of repeat title frames (for movie).
16	76-80	40	SC 4020 Y raster for frame number and title.

Card #5 (Format: 13I5)

Word	Columns	Normal Value	Description
1	1-5	480	SC 4020 X raster for RA (horizontal title).
2	6-10	980	SC 4020 Y raster for RA (horizontal title).
3	11-15	60	SC 4020 X raster for DEC (vertical title).
4	16-20	500	SC 4020 Y raster for DEC (vertical title).
5	21-25	2	X magnification for words 1 and 3 above.
6	26-30	2	Y magnification for words 2 and 4 above.
7	31-35	50	X and Y displacement degrees, times 100, for horizontal and vertical grid markers.
8	36-40	100	X correction degrees, times 100, for horizontal grid markers.
9	41-45	1	X magnification for grid markers.
10	46-50	1	Y magnification for grid markers.
11	51-55	2	Number of degrees between markers.
12	56-60	50	Degree width of individual gegenschein raster, times 100.
13	61-65	50	Degree height of individual gegenschein raster, times 100.

Card #6 (Format: 16I5)

Word	Columns	Normal Value	Description
1	1-5	-1	Identifies the card as a master overlay and controls Photo Tape swapping as follows: -1 = "new" overlay - do not swap Photo Tape. -2 = "new" overlay - swap to the next Photo Tape.
2	6-10		Display data type indicator: 1 = display raw data 2 = display corrected data 0 = both raw and corrected data.
3	11-15		Number of repeat frames after the initial frame (for movie).
4	16-20		Width in degrees of RA display.
5	21-25		Height in degrees of DEC display.
6	26-30		SC 4020 low density level.
7	31-35		SC 4020 high density level.
8-11	36-55		Blank
12	56-60		Gegenschein start raster number.
13	61-65	704	Gegenschein stop raster number.
14	66-70		Raster correction (tune-up) flag: 0 = none 1 = fine -1 = coarse
15	71-75		Number of raw data Frame Correction Cards trailing this card.
16	76-80		Number of corrected data Frame Correction Cards trailing this card.

Star Data Cards

Word	Columns	Format	Description
1	1-5	I5	Star intensity: 0 to 32760 in the progression 0, 8, 16...32760.
2	6-15	F10.3	Star celestial right ascension.
3	16-25	F10.3	Star celestial declination.

Milky Way Data Cards (Format: 8F9.4)

Word	Columns	Description
1	1-9	Element 1: celestial RA.
2	10-18	Element 1: celestial DEC.
3	19-27	Element 2: celestial RA.
4	28-36	Element 2: celestial DEC.
5	37-45	Element 3: celestial RA.
6	46-54	Element 3: celestial DEC.
7	55-63	Element 4: celestial RA.
8	64-72	Element 4: celestial DEC.

Frame Edit Cards (Format: 16I5)

Word	Columns	Description
1	1-5	Display frame number.
2	6-10	Data flag: 1 = raw data 2 = corrected data 0 = both
3	11-15	Number of repeat frames after initial frame.
4	16-20	Degree width: RA.
5	21-25	Degree height: DEC.
6	26-30	SC 4020 low intensity level.
7	31-35	SC 4020 high intensity level.
8	36-40	Raw data low intensity level.
9	41-45	Raw data high intensity level.
10	46-50	Corrected data low intensity level.
11	51-55	Corrected data high intensity level.
12	56-60	Gegenschein start raster number.
13	61-65	Gegenschein stop raster number.
14	66-70	SC 4020 tune-up flag: 0 = none 1 = fine -1 = coarse
15	71-75	Either the number of raw data Frame Correction Cards trailing this card or a frame averaging flag: -1 = average in the frame. -2 = average in and plot the frame.
16	76-80	Either the number of corrected data Frame Correction Cards trailing this card or a frame averaging termination indicator in the format -xx, where xx = bit rate (1, 8, 64).

Frame Correction Card (2I5)

Word	Columns	Description
1	1-5	Right Ascension of the raster to be corrected.
2	6-10	Declination of the raster to be corrected.

RUN EXECUTION

Machine Requirements (Univac 1108)

Device	Yes	No	Amount/Number
Tape Drives	X		4
Card Reader	X		
Card Punch	X		
Printer	X		

Input-Output

	Description	Device
INPUT	Program Tape (TASK2)	Tape A
	Gegenschein Data Tape(s) (optional)	Tape D
	Photo Tape(s)	Tape C
	Run Deck	Card Reader
OUTPUT	Plot (Movie) Tape(s)	Tape C
	Photo Data Summary	Printer
	Movie Summary	Printer
	Edit Cards (if gegenschein tape used)	Punch

Tape Arrangement

	Description	Device	Op Label	Disposition
INPUT	Program Tape	A	TASK2	
	Gegenschein Data	D	GEG	
	Photo Tape	C	PHOTO	
OUTPUT	Plot Tape	B	PLOT	

Jump Switches

None

Run Deck Set-Up

▽ RUN (name)

▽ ASG A = TASK2

▽ ASG B = PLOT

▽ ASG C = PHOTO

▽ ASG D = GEG (optional)

▽ XQT CUR

TRW A

IN A

TRI A

▽ XQT GEGEN

Basic Input Cards (6 cards)

Star Data Cards (optional)

Blank Card

Milky Way Data Cards (optional)

Blank Card

Edit Cards (optional)

Blank Card

Blank Card

▽ FIN

Messages

Message	
A	FRAME NO. (XXX...8I15...XXX)
B	TOSSED OUT GEG FRAME
C	SWAPPED GEG
D	GEG ALL DONE DID NOT SWAP PHOTO
E	ERROR PHOTO
F	NEW MASTER OVERLAY (XXX...16I5...XXX)
G	SWAP 'PHOTO'

Message	Appears On	Program Action	Operator Action
A	Printer	Continues	None
B	Printer	Continues	None
C	Printer	Continues	None
D	Printer	Continues	None
E	Printer	Continues	None
F	Printer	Continues	None
G	Printer	Continues	Mount and ready new Photo Tape.

3.0 OUTPUT EXAMPLES

Figure 3-1 is an example of the printed output produced by the Processing Program; Figure 3-2 is an example of the Display Program output.

DATA PROCESSING FOR EGO EXPERIMENT NO. 20

[illegible]

LINE NO. 8	LINE NO. 9	LINE NO. 10	LINE NO. 11
1.380	1.010	7.500	7.500
1.380	1.005	7.050	7.050
1.380	1.000	6.600	6.600
1.380	.995	6.150	6.150
1.380	.990	5.700	5.700
1.380	.985	5.250	5.250
1.380	.980	4.800	4.800
1.380	.975	4.350	4.350
1.380	.970	3.900	3.900
1.380	.965	3.450	3.450
1.380	.960	3.000	3.000
1.380	.955	2.550	2.550
1.380	.950	2.100	2.100
1.380	.945	1.650	1.650
1.380	.940	1.200	1.200
1.380	.935	.750	.750
1.380	.930	.300	.300
1.380	.925	.000	.000
1.380	.920	.000	.000
1.380	.915	.000	.000
1.380	.910	.000	.000
1.380	.905	.000	.000
1.380	.900	.000	.000
1.380	.895	.000	.000
1.380	.890	.000	.000
1.380	.885	.000	.000
1.380	.880	.000	.000
1.380	.875	.000	.000
1.380	.870	.000	.000
1.380	.865	.000	.000
1.380	.860	.000	.000
1.380	.855	.000	.000
1.380	.850	.000	.000
1.380	.845	.000	.000
1.380	.840	.000	.000
1.380	.835	.000	.000
1.380	.830	.000	.000
1.380	.825	.000	.000
1.380	.820	.000	.000
1.380	.815	.000	.000
1.380	.810	.000	.000
1.380	.805	.000	.000
1.380	.800	.000	.000
1.380	.795	.000	.000
1.380	.790	.000	.000
1.380	.785	.000	.000
1.380	.780	.000	.000
1.380	.775	.000	.000
1.380	.770	.000	.000
1.380	.765	.000	.000
1.380	.760	.000	.000
1.380	.755	.000	.000
1.380	.750	.000	.000
1.380	.745	.000	.000
1.380	.740	.000	.000
1.380	.735	.000	.000
1.380	.730	.000	.000
1.380	.725	.000	.000
1.380	.720	.000	.000
1.380	.715	.000	.000
1.380	.710	.000	.000
1.380	.705	.000	.000
1.380	.700	.000	.000
1.380	.695	.000	.000
1.380	.690	.000	.000
1.380	.685	.000	.000
1.380	.680	.000	.000
1.380	.675	.000	.000
1.380	.670	.000	.000
1.380	.665	.000	.000
1.380	.660	.000	.000
1.380	.655	.000	.000
1.380	.650	.000	.000
1.380	.645	.000	.000
1.380	.640	.000	.000
1.380	.635	.000	.000
1.380	.630	.000	.000
1.380	.625	.000	.000
1.380	.620	.000	.000
1.380	.615	.000	.000
1.380	.610	.000	.000
1.380	.605	.000	.000
1.380	.600	.000	.000
1.380	.595	.000	.000
1.380	.590	.000	.000
1.380	.585	.000	.000
1.380	.580	.000	.000
1.380	.575	.000	.000
1.380	.570	.000	.000
1.380	.565	.000	.000
1.380	.560	.000	.000
1.380	.555	.000	.000
1.380	.550	.000	.000
1.380	.545	.000	.000
1.380	.540	.000	.000
1.380	.535	.000	.000
1.380	.530	.000	.000
1.380	.525	.000	.000
1.380	.520	.000	.000
1.380	.515	.000	.000
1.380	.510	.000	.000
1.380	.505	.000	.000
1.380	.500	.000	.000
1.380	.495	.000	.000
1.380	.490	.000	.000
1.380	.485	.000	.000
1.380	.480	.000	.000
1.380	.475	.000	.000
1.380	.470	.000	.000
1.380	.465	.000	.000
1.380	.460	.000	.000
1.380	.455	.000	.000
1.380	.450	.000	.000
1.380	.445	.000	.000
1.380	.440	.000	.000
1.380	.435	.000	.000
1.380	.430	.000	.000
1.380	.425	.000	.000
1.380	.420	.000	.000
1.380	.415	.000	.000
1.380	.410	.000	.000
1.380	.405	.000	.000
1.380	.400	.000	.000
1.380	.395	.000	.000
1.380	.390	.000	.000
1.380	.385	.000	.000
1.380	.380	.000	.000
1.380	.375	.000	.000
1.380	.370	.000	.000
1.380	.365	.000	.000
1.380	.360	.000	.000
1.380	.355	.000	.000
1.380	.350	.000	.000
1.380	.345	.000	.000
1.380	.340	.000	.000
1.380	.335	.000	.000
1.380	.330	.000	.000
1.380	.325	.000	.000
1.380	.320	.000	.000
1.380	.315	.000	.000
1.380	.310	.000	.000
1.380	.305	.000	.000
1.380	.300	.000	.000
1.380	.295	.000	.000
1.380	.290	.000	.000
1.380	.285	.000	.000
1.380	.280	.000	.000
1.380	.275	.000	.000
1.380	.270	.000	.000
1.380	.265	.000	.000
1.380	.260	.000	.000
1.380	.255	.000	.000
1.380	.250	.000	.000
1.380	.245	.000	.000
1.380	.240	.000	.000
1.380	.235	.000	.000
1.380	.230	.000	.000
1.380	.225	.000	.000
1.380	.220	.000	.000
1.380	.215	.000	.000
1.380	.210	.000	.000
1.380	.205	.000	.000
1.380	.200	.000	.000
1.380	.195	.000	.000
1.380	.190	.000	.000
1.380	.185	.000	.000
1.380	.180	.000	.000
1.380	.175	.000	.000
1.380	.170	.000	.000
1.380	.165	.000	.000
1.380	.160	.000	.000
1.380	.155	.000	.000
1.380	.150	.000	.000
1.380	.145	.000	.000
1.380	.140	.000	.000
1.380	.135	.000	.000
1.380	.130	.000	.000
1.380	.125	.000	.000
1.380	.120	.000	.000
1.380	.115	.000	.000
1.380	.110	.000	.000
1.380	.105	.000	.000
1.380	.100	.000	.000
1.380	.095	.000	.000
1.380	.090	.000	.000
1.380	.085	.000	.000
1.380	.080	.000	.000
1.380	.075	.000	.000
1.380	.070	.000	.000
1.380	.065	.000	.000
1.380	.060	.000	.000
1.380	.055	.000	.000
1.380	.050	.000	.000
1.380	.045	.000	.000
1.380	.040	.000	.000
1.380	.035	.000	.000
1.380	.030	.000	.000
1.380	.025	.000	.000
1.380	.020	.000	.000
1.380	.015	.000	.000
1.380	.010	.000	.000
1.380	.005	.000	.000
1.380	.000	.000	.000

Figure 3-1. Processing Program - Output Example (continued)

1.300	-3.980	126.59	72 0	.870	-3.953	239.50	136 0	.410	-3.927	515.97	296 0	.000	-3.900	164.06	96 0
1.275	-4.480	181.64	0 0	.860	-4.453	245.06	112 0	.405	-4.427	338.24	160 0	.000	-4.400	195.94	96 0
1.250	-4.900	236.09	72 0	.850	-4.867	272.45	88 0	.400	-4.833	374.27	128 0	.000	-4.800	222.24	80 0
1.225	-5.320	272.10	64 0	.840	-5.280	316.10	96 0	.395	-5.240	437.80	88 0	.000	-5.200	334.87	72 0
1.200	-5.740	308.64	56 0	.830	-5.693	358.21	72 0	.390	-5.647	504.32	96 0	.000	-5.600	373.66	64 0
1.175	-6.160	344.84	56 0	.820	-6.117	398.05	56 0	.385	-6.071	571.37	72 0	.000	-6.030	414.22	144 0
1.150	-6.580	381.07	56 0	.810	-6.520	434.27	48 0	.380	-6.475	600.18	48 0	.000	-6.430	450.00	104 0
1.125	-7.000	417.27	48 0	.800	-6.933	469.92	48 0	.375	-6.887	666.02	56 0	.000	-6.840	490.00	72 0
1.300	7.508	.00	40 0	-.730	7.516	.00	32 0	-1.210	7.524	.00	48 0	-1.690	7.532	.00	40 0
1.275	7.058	.00	32 0	-.740	7.066	.00	40 0	-1.220	7.074	.00	48 0	-1.700	7.082	.00	40 0
1.250	6.606	.00	32 0	-.750	6.616	.00	56 0	-1.230	6.624	.00	56 0	-1.710	6.632	.00	32 0
1.225	6.158	.00	32 0	-.760	6.166	.00	48 0	-1.240	6.174	.00	48 0	-1.720	6.182	.00	32 0
1.200	5.698	2105.28	40 0	-.770	5.666	4335.33	72 0	-1.250	5.674	2133.34	32 0	-1.730	5.682	3200.00	32 0
1.175	5.208	238.48	48 0	-.780	5.216	827.57	48 0	-1.260	5.224	800.00	40 0	-1.740	5.232	1142.84	40 0
1.150	4.758	330.75	56 0	-.790	4.766	547.01	64 0	-1.270	4.774	304.77	32 0	-1.750	4.782	519.48	40 0
1.125	4.304	260.40	56 0	-.800	4.308	451.26	88 0	-1.280	4.312	182.85	32 0	-1.760	4.316	342.86	48 0
1.300	3.804	188.22	64 0	-.810	3.808	300.00	96 0	-1.290	3.812	142.84	40 0	-1.770	3.816	260.46	56 0
1.275	3.354	185.24	88 0	-.820	3.358	503.33	224 0	-1.310	3.362	123.07	48 0	-1.795	3.366	244.08	72 0
1.250	2.904	130.08	80 0	-.830	2.908	519.18	296 0	-1.330	2.912	96.00	48 0	-1.820	2.916	379.01	144 0
1.225	2.454	172.93	128 0	-.840	2.458	414.43	288 0	-1.350	2.462	88.00	56 0	-1.845	2.466	391.55	184 0
1.200	2.004	152.06	128 0	-.850	2.008	383.95	304 0	-1.370	2.012	89.15	64 0	-1.870	2.016	361.71	208 0
1.175	1.508	131.88	120 0	-.875	1.516	291.65	248 0	-1.390	1.524	112.82	88 0	-1.890	1.532	342.05	224 0
1.150	1.012	142.80	136 0	-.900	1.024	279.25	248 0	-1.410	1.036	97.92	80 0	-1.910	1.048	412.70	288 0
1.125	.516	149.18	144 0	-.925	.532	371.28	336 0	-1.430	.548	113.57	96 0	-1.930	.564	328.80	240 0
1.300	.020	181.46	176 0	-.950	.040	288.55	264 0	-1.450	.060	103.49	88 0	-1.950	.080	356.66	264 0
1.275	.468	240.35	232 0	-.940	.436	236.09	216 0	-1.435	.404	141.12	120 0	-1.930	.372	421.51	312 0
1.250	.964	261.14	248 0	-.930	.928	362.44	328 0	-1.420	.892	132.50	112 0	-1.910	.856	533.51	392 0
1.225	1.410	234.79	216 0	-.920	1.370	327.17	288 0	-1.405	1.330	125.05	104 0	-1.890	1.290	540.57	392 0
1.200	1.910	274.32	240 0	-.910	1.870	314.16	264 0	-1.390	1.830	152.88	120 0	-1.870	1.790	578.54	408 0
1.175	2.414	270.00	216 0	-.905	2.378	266.40	160 0	-1.385	2.342	143.42	104 0	-1.860	2.306	598.58	392 0
1.150	2.914	274.00	200 0	-.900	2.878	192.85	136 0	-1.380	2.842	196.66	128 0	-1.850	2.806	772.92	456 0
1.125	3.418	332.21	216 0	-.895	3.386	232.27	144 0	-1.375	3.354	252.58	144 0	-1.840	3.322	1380.54	704 0
1.100	3.868	313.10	176 0	-.890	3.836	226.44	120 0	-1.370	3.804	281.11	104 0	-1.830	3.772	936.58	384 0
1.075	4.368	295.66	136 0	-.880	4.336	244.71	104 0	-1.355	4.304	281.11	104 0	-1.810	4.272	933.24	280 0
1.050	4.764	423.50	144 0	-.870	4.728	283.89	88 0	-1.340	4.692	338.45	88 0	-1.790	4.656	1066.69	224 0
1.025	5.160	560.00	112 0	-.860	5.120	319.98	56 0	-1.325	5.080	480.02	72 0	-1.770	5.040	1530.50	176 0
1.000	5.560	1011.47	88 0	-.850	5.520	708.85	56 0	-1.310	5.480	1028.59	72 0	-1.750	5.440	2933.39	176 0
1.075	6.010	1185.15	64 0	-.840	5.970	999.98	48 0	-1.295	5.930	1523.78	64 0	-1.730	5.890	4114.22	144 0
1.050	6.460	1994.08	56 0	-.830	6.420	1338.48	40 0	-1.280	6.380	1391.30	32 0	-1.710	6.340	5200.00	104 0
1.025	6.860	4371.46	64 0	-.820	6.820	1076.92	40 0	-1.265	6.780	1630.36	40 0	-1.690	6.740	7200.00	72 0
1.300	7.540	.00	48 0	-2.700	7.575	.00	32 0	-3.230	7.610	.00	40 0	-3.750	7.645	.00	16 0
1.275	7.090	.00	32 0	-2.720	7.125	.00	24 0	-3.255	7.160	.00	40 0	-3.780	7.195	.00	24 0
1.250	6.640	.00	40 0	-2.740	6.670	.00	24 0	-3.260	6.700	.00	32 0	-3.810	6.730	.00	40 0
1.225	6.190	.00	40 0	-2.760	6.220	.00	24 0	-3.305	6.250	.00	32 0	-3.840	6.280	.00	24 0
1.200	5.690	.00	40 0	-2.780	5.720	.00	32 0	-3.330	5.750	.00	24 0	-3.870	5.780	.00	32 0
1.175	5.240	1600.00	40 0	-2.800	5.270	3200.00	32 0	-3.355	5.300	.00	40 0	-3.900	5.330	.00	40 0
1.150	4.790	1018.19	56 0	-2.820	4.815	1333.34	32 0	-3.380	4.840	466.65	56 0	-3.930	4.865	.00	32 0
1.125	4.320	480.00	48 0	-2.840	4.350	480.00	24 0	-3.405	4.380	1920.00	48 0	-3.960	4.410	3076.92	40 0
1.100	3.820	320.02	48 0	-2.860	3.850	282.36	24 0	-3.430	3.880	1531.94	72 0	-3.990	3.910	1600.00	40 0
1.075	3.370	319.97	72 0	-2.880	3.400	296.28	40 0	-3.460	3.430	1156.61	96 0	-4.010	3.460	545.45	40 0
1.050	2.920	266.54	80 0	-2.900	2.950	280.00	56 0	-3.490	2.980	1533.27	184 0	-4.030	3.010	625.00	24 0
1.025	2.470	164.28	64 0	-2.920	2.500	332.50	104 0	-3.520	2.530	2200.00	352 0	-4.050	2.560	470.60	40 0
1.000	2.020	179.76	80 0	-2.940	2.050	353.60	120 0	-3.550	2.080	1038.53	216 0	-4.070	2.110	266.66	32 0
1.455	1.540	160.00	80 0	-2.985	1.575	396.87	152 0	-3.550	1.610	1225.73	304 0	-4.065	1.645	266.66	40 0

Figure 3-1. Processing Program - Output Example (continued)

-2.470	1.060	144.10	60 0	-2.990	1.160	387.91	168 0	-3.550	1.146	1245.92	360 0	-4.060	1.180	228.56	40 0
-2.465	.580	133.36	60 0	-2.995	.630	353.64	168 0	-3.550	.680	1501.58	488 0	-4.055	.730	205.12	40 0
-2.500	.100	128.00	60 0	-3.000	.160	304.00	152 0	-3.550	.220	2125.01	744 0	-4.500	.280	297.66	64 0
-2.480	-.340	126.96	80 0	-2.965	-.280	329.45	168 0	-3.550	-.230	2200.18	792 0	-4.045	-.175	278.27	64 0
-2.460	-.820	114.26	72 0	-2.970	-.755	329.45	168 0	-3.550	-.590	2257.76	824 0	-4.040	-.625	272.32	64 0
-2.440	-1.250	141.94	68 0	-2.955	-1.160	352.60	176 0	-3.550	-1.110	1509.91	536 0	-4.035	-1.040	243.49	56 0
-2.420	-1.750	119.02	72 0	-2.940	-1.670	335.28	160 0	-3.510	-1.590	894.06	304 0	-4.030	-1.510	409.29	88 0
-2.435	-.270	154.35	68 0	-2.915	-.2160	327.31	144 0	-3.470	-2.090	929.09	268 0	-3.980	-2.000	336.83	64 0
-2.390	-2.770	141.19	72 0	-2.890	-2.675	311.04	120 0	-3.430	-2.580	794.08	224 0	-3.930	-2.485	350.00	56 0
-2.375	-3.290	186.06	80 0	-2.865	-3.185	400.60	128 0	-3.390	-3.080	921.12	152 0	-3.880	-2.975	448.00	56 0
-2.360	-3.740	214.92	72 0	-2.840	-3.655	533.38	128 0	-3.350	-3.530	921.12	152 0	-3.830	-3.425	622.22	56 0
-2.340	-4.240	228.59	56 0	-2.840	-4.135	624.30	136 0	-3.350	-4.030	1113.09	128 0	-3.830	-3.925	738.48	48 0
-2.320	-4.620	250.00	40 0	-2.840	-4.520	945.46	104 0	-3.350	-4.420	1599.96	120 0	-3.830	-4.320	1400.00	56 0
-2.300	-5.000	444.44	40 0	-2.840	-4.905	1476.96	96 0	-3.350	-4.810	1920.00	96 0	-3.830	-4.715	2074.07	56 0
-2.280	-5.400	711.10	32 0	-2.840	-5.305	2057.11	72 0	-3.350	-5.210	1860.05	56 0	-3.830	-5.115	2500.00	40 0
-2.260	-5.850	1599.98	48 0	-2.840	-5.755	2960.00	64 0	-3.350	-5.660	2000.00	40 0	-3.830	-5.565	3636.36	40 0
-2.240	-6.300	2133.31	32 0	-2.840	-6.205	3333.32	40 0	-3.350	-6.110	3200.00	32 0	-3.830	-6.015	.00	48 0
-2.220	-6.700	.00	24 0	-2.840	-6.605	.00	40 0	-3.350	-6.510	.00	32 0	-3.830	-6.415	.00	32 0
LINE NO.20															
-1.350	7.680	.00	32 0	-4.900	7.715	.00	40 0	-4.900	7.715	.00	40 0	-4.900	7.715	.00	40 0
-1.370	7.230	.00	40 0	-4.930	7.265	.00	50 0	-4.930	7.265	.00	50 0	-4.930	7.265	.00	50 0
-4.400	6.760	.00	40 0	-4.960	6.790	.00	56 0	-4.960	6.790	.00	56 0	-4.960	6.790	.00	56 0
-4.430	6.310	.00	40 0	-4.990	6.340	.00	56 0	-4.990	6.340	.00	56 0	-4.990	6.340	.00	56 0
-4.460	5.810	.00	48 0	-5.020	5.840	.00	32 0	-5.020	5.840	.00	32 0	-5.020	5.840	.00	32 0
-4.490	5.360	.00	40 0	-5.050	5.390	.00	48 0	-5.050	5.390	.00	48 0	-5.050	5.390	.00	48 0
-4.520	4.890	.00	32 0	-5.080	4.915	.00	40 0	-5.080	4.915	.00	40 0	-5.080	4.915	.00	40 0
-4.550	4.440	.00	40 0	-5.110	4.470	.00	48 0	-5.110	4.470	.00	48 0	-5.110	4.470	.00	48 0
-1.500	3.940	3636.36	40 0	-5.140	3.970	.00	56 0	-5.140	3.970	.00	56 0	-5.140	3.970	.00	56 0
-4.585	3.490	2400.00	48 0	-5.170	3.520	.00	40 0	-5.170	3.520	.00	40 0	-5.170	3.520	.00	40 0
-1.610	3.040	1500.00	48 0	-5.140	3.070	4666.65	56 0	-5.140	3.070	4666.65	56 0	-5.140	3.070	4666.65	56 0
-1.625	2.590	1021.30	48 0	-5.140	2.620	4380.84	56 0	-5.140	2.620	4380.84	56 0	-5.140	2.620	4380.84	56 0
-4.600	2.140	1107.72	72 0	-5.140	2.170	2560.00	64 0	-5.140	2.170	2560.00	64 0	-5.140	2.170	2560.00	64 0
-4.630	1.690	1000.00	60 0	-5.130	1.715	2680.64	60 0	-5.130	1.715	2680.64	60 0	-5.130	1.715	2680.64	60 0
-1.620	1.220	1204.34	112 0	-5.120	1.260	1326.54	64 0	-5.120	1.260	1326.54	64 0	-5.120	1.260	1326.54	64 0
-1.610	.760	1142.88	120 0	-5.110	.835	2095.19	68 0	-5.110	.835	2095.19	68 0	-5.110	.835	2095.19	68 0
-4.600	.340	904.39	104 0	-5.100	.415	1331.94	72 0	-5.100	.415	1331.94	72 0	-5.100	.415	1331.94	72 0
-4.600	-.120	1666.62	128 0	-5.135	-.085	405.66	48 0	-5.135	-.085	405.66	48 0	-5.135	-.085	405.66	48 0
-1.600	-.560	1152.00	144 0	-5.110	-.560	962.46	56 0	-5.110	-.560	962.46	56 0	-5.110	-.560	962.46	56 0
-4.600	-.970	1408.00	176 0	-5.115	-.505	1560.09	94 0	-5.115	-.505	1560.09	94 0	-5.115	-.505	1560.09	94 0
-4.600	-1.430	1666.61	176 0	-5.120	-1.355	827.57	48 0	-5.120	-1.355	827.57	48 0	-5.120	-1.355	827.57	48 0
-4.600	-1.910	1676.22	176 0	-5.120	-1.825	925.09	48 0	-5.120	-1.825	925.09	48 0	-5.120	-1.825	925.09	48 0
-4.600	-2.390	1832.40	160 0	-5.120	-2.300	1200.00	48 0	-5.120	-2.300	1200.00	48 0	-5.120	-2.300	1200.00	48 0
-4.600	-2.870	1800.04	104 0	-5.120	-2.770	1595.98	48 0	-5.120	-2.770	1595.98	48 0	-5.120	-2.770	1595.98	48 0
-4.600	-3.320	2666.64	120 0	-5.120	-3.220	2181.84	48 0	-5.120	-3.220	2181.84	48 0	-5.120	-3.220	2181.84	48 0
-4.600	-3.820	3999.96	120 0	-5.120	-3.720	2686.68	40 0	-5.120	-3.720	2686.68	40 0	-5.120	-3.720	2686.68	40 0
-4.600	-4.220	5203.00	104 0	-5.120	-4.120	4000.00	40 0	-5.120	-4.120	4000.00	40 0	-5.120	-4.120	4000.00	40 0
-4.600	-4.620	5714.32	80 0	-5.120	-4.520	.00	40 0	-5.120	-4.520	.00	40 0	-5.120	-4.520	.00	40 0
-4.600	-5.020	.00	60 0	-5.120	-4.920	.00	48 0	-5.120	-4.920	.00	48 0	-5.120	-4.920	.00	48 0
-4.600	-5.470	.00	56 0	-5.120	-5.370	.00	32 0	-5.120	-5.370	.00	32 0	-5.120	-5.370	.00	32 0
-4.600	-5.920	.00	64 0	-5.120	-5.820	.00	40 0	-5.120	-5.820	.00	40 0	-5.120	-5.820	.00	40 0
-4.600	-6.320	.00	40 0	-5.120	-6.220	.00	32 0	-5.120	-6.220	.00	32 0	-5.120	-6.220	.00	32 0

Figure 3-1. Processing Program - Output Example (continued)

THE GEGER-SCHF IN PHOTOMETRY EXPERIMENT

TAPE UNIT FOR 'GEG'		TAPE UNIT FOR 'PHOTO'		TAPE UNIT FOR 'PLOT'	
3	2	1	130	1	130
1 SC 4020 CAMERA NUMBER	2 BLANK GEG FRAMES ONLY	1	130	1	130
412 WORDS PER ID RECORD	10 WORDS PER DATA RECORD	9	9	9	9
50 MINIMUM ZERO RA VALUES	10 MINIMUM SC4020 X VALUE	10	10	10	10
1013 MAXIMUM SC4020 X VALUE	1013 MAXIMUM SC4020 Y VALUE	5	5	5	5
16 WORDS PER PARAMETER CD.	60R PLOT OUTPUT BUFFER SIZE	22	22	22	22
32 DECLINATION ROWS	0 INPUT 'GEG' TAPES	0	0	0	0
8 PLOT DENSITY FACTOR	0 COURSE ERROR CORRECTION	20	20	20	20
2000000 WORDS PER PLOT TAPE	0 1=PRINT RA AND DEC	0	0	0	0
1 0=NO.1=BOX.2=50.3=50	1 1=PRINT CYCLE TIME	20	20	20	20
20 Y RASTER FOR FRAME TITLE	70 X RASTER FOR FRAME TITLE	500	500	500	500
1020 Y RASTER FOR RA	3 Y RASTER FOR DEC	500	500	500	500
1 X MAG. FOR RA/DEC	1 Y MAG. FOR RA/DEC	50	50	50	50
50 X CORR. *100	1 X MAG. FOR GRID	1	1	1	1
2 DEG. BETWEEN MARKERS	15 DEGREES WIDTH	20	20	20	20
50 RASTER WIDTH *100	50 RASTER HEIGHT *100	0	0	0	0
FILTER	RAW HI	COR LO	COR HI		
1 1	3000	300	30000	1	704
2 2	3000	300	30000	1	704
3 3	3000	300	30000	1	704
4 4	3000	300	30000	1	704
5 5	3000	300	30000	1	704
6 6	3000	300	30000	1	704
7 7	3000	300	30000	1	704
START FLIK CYCLE					
1 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	67169				
1 DAY=337	SEC= 763 FIL=1 TA= 0				
2 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	131				
2 DAY=337	SEC= 865 FIL=1 TA= 0				
3 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	130				
3 DAY=337	SEC= 966 FIL=1 TA= 0				
4 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	131				
4 DAY=337	SEC= 1067 FIL=1 TA= 0				
5 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	130				
5 DAY=337	SEC= 1169 FIL=1 TA= 0				
6 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	131				
6 DAY=337	SEC= 1270 FIL=1 TA= 0				
7 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	130				
7 DAY=337	SEC= 1371 FIL=1 TA= 0				
8 FRAME	2 12 15 20	2	16	20	3000
ELAPSED SEC. =	130				
8 DAY=337	SEC= 1473 FIL=1 TA= 0				

Figure 3-2. Display Program - Output Example

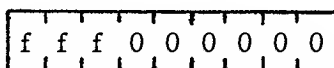
4. DATA FORMATS

TELEMETRY DATA

Telemetered data can be simultaneously transmitted in realtime to various ground stations and recorded by two on-board tape recorders. Realtime transmissions are made at 64, 8, or 1 kilobits per second; tape recorded data (playback data) is recorded at 1 kilobit per second and transmitted to receiving stations at 64 kilobits per second. Realtime and playback transmissions are controlled by the ground stations.

Both realtime and playback data are telemetered in frames consisting of 128 9-bit words from two equipment groups, EG1 and EG2. EG1 usually controls realtime data; EG2 usually controls playback data. In telemetry from either group, gegenschein experiment data occupies words 11, 17, and 18 (refer to Figures 4-1 and 4-2).

Word 11 contains the filter number in the three most significant bits as shown below; the last six bits are not used.

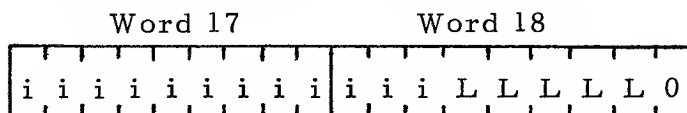


where

fff = filter wheel position as follows:

100	calibrate position
101	filter #1: green
001	filter #2: green polarized
011	filter #3: green polarized
010	filter #4: infrared
110	filter #5: ultraviolet
111	no sun
000	experiment off

Words 17 and 18 contain the intensity value for a single picture element and the raster line number in the following format:



where

i = 12-bit element intensity value in the binary equivalent of decimal numbers in the arithmetic progression 0, 8, 16, 32... 32760.

L = line of scan (0 to 21).

HORIZONTAL MATRIX LINES		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
RI1	SYNC WORD #1	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	SYNC WORD #2	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
RI2	SYNC WORD #3	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	SYNC WORD #4	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
RI3	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
RI4	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
RI5	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
RI6	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
RI7	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
RI8	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
	ACCUMULATED TIME (SECS)	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017

33	Δ	040	34	041	35	042																																																																																																																	
ACCUMULATED TIME (SECS)																																																																																																																							
49	060	50	061	51	062																																																																																																																		
7	7	7	7	7	7	7																																																																																																																	
85	100	66	101	67	102																																																																																																																		
81	120	82	121	83	122	84	123	85	124	86	125	87	126	88	127	89	130	90	131	91	132	92	133	93	134	94	135	95	136	96	137	138	99																																																																																						
97	140	98	141	99	142	100	143	101	144	102	145	103	146	104	147	105	150	106	151	107	152	108	153	109	154	110	155	111	156	112	157	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
SUBCOM 1 SUBCOM 2 SUBCOM 3																																																																																																																							
DATA WORD DATA WORD DATA WORD																																																																																																																							
113	160	114	161	115	162	116	163	117	164	118	165	119	166	120	167	121	170	122	171	123	172	124	173	125	174	126	175	127	176	128	177	129	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200																																																																		
9	9	8	8	8	8	8																																																																																																																	
PARTICLE COUNT																																																																																																																							
LOW CHAMBER DATA																																																																																																																							
KI01	KI02	KI03	KI04	KI05	KI06	KI07	KI08	KI09	KI10	KI11	KI12	KI13	KI14	KI15	KI16	KI17	KI18	KI19	KI20	KI21	KI22	KI23	KI24	KI25	KI26	KI27	KI28	KI29	KI30	KI31	KI32	KI33	KI34	KI35	KI36	KI37	KI38	KI39	KI40	KI41	KI42	KI43	KI44	KI45	KI46	KI47	KI48	KI49	KI50	KI51	KI52	KI53	KI54	KI55	KI56	KI57	KI58	KI59	KI60	KI61	KI62	KI63	KI64	KI65	KI66	KI67	KI68	KI69	KI70	KI71	KI72	KI73	KI74	KI75	KI76	KI77	KI78	KI79	KI80	KI81	KI82	KI83	KI84	KI85	KI86	KI87	KI88	KI89	KI90	KI91	KI92	KI93	KI94	KI95	KI96	KI97	KI98	KI99	KI00																				

VERTICAL MATRIX LINES

Figure 4-1. Main Telemetry Format - EGI

DECOM TAPE

The Decom Tape format is shown in Figures 4-3, 4-4, and 4-5. The tape may contain up to nine files; each file contains the data received at a data acquisition station during the spacecraft's pass over that station.

Character	Description
1-5+Space	Satellite Identification (assigned after launch) Example: 66491 where: 66 = year of launch 49 = numbered launches from start of year 1 = object
7-8+Space	Year
10-12+Space	Station Number. Example: 001 = Blossom Point 020 = Rosman
14-15+Space	Analog File Number.
17-20+Space	Analog Tape Number.
22-23+Space	Buffer File Number.
25-28+Space	Buffer Tape Number.
30-32+Space	Date of data digitization (day of year).
34-66	Will be identical to character 1-33 unless an error was found in those characters. If that is the case, then this portion of the record will contain the corrected values of that field.
67+Space	Type of data contained in file: 0 = 1 kilobit real time 1 = 8 kilobit real time 2 = 64 kilobit real time 3 = command storage playback
69-71	Day of year.
73-77+Space	Seconds of day; start time of data.

Figure 4-3. Decom Tape Format: Label Record

Character	Description
79+Space	Is Flexible Format in use? 1 = Yes 0 = No
81-82	Flexible Format Number
83-88	Blank
89+Space	Equipment Group in use (1 or 2)
91-94+Space	Master Binary Tape Number
96-97+Space	Master Binary File Number
99-100+Space	A/D line operator ID
102-103	A/D line ID
104-113	Blank
114-115	Reel Sequence Number
116-118	Run Number
119-120	Experiment Number

Figure 4-3. Decom Tape Format: Label Record (continued)

Tele. Group			
S/C Word	Frame Number	Character	Description
		1-6	Time field: milliseconds of day (GMT) for the first bit of S/C word #1.
		7-8	Day count of year.
98	23	9-10	Yaw error signal.
98	24	11-12	Array error signal.
99	30	13-14	SOEP #1 (-y face).
99	37	15-16	Temperature of body near module #13.
98	47	17-18	Load Bus Voltage.
66	1	19-20	ID word (once per subcom sequence): <div style="margin-left: 40px;"> <u>Bit</u> <u>Item</u> 1 Data Type 2-4 Mode 5-9 Flexible Format No. </div>
67	1	21-22	ID word - same as above.
99	40	23-24	SOEP #1 (+y face).
		25-30	Spare characters.
		31-32+18N	Frame status field (see Figure 4-5).
33	N	33-34+18N	Spacecraft accumulated time in seconds.
34	N	35-36+18N	
35	N	37-38+18N	
65	N	39-40+18N	
			Data identification word: <div style="margin-left: 40px;"> <u>Bit</u> <u>Item</u> 1-7 Subcom position 8 Execute relay state 9 Cross strap </div>
11	N	41-42+18N	Digital experiment data.
17	N	43-44+18N	
18	N	45-46+18N	
		47-48+18N	Flag signifying end.

N = 0, 1, 2, ... 126, 127

Figure 4-4. Decom Tape Format: Data Records

Bit **	State	Representation for F1, Quality Control Status *
1-6		Total bit errors in the 27 bit frame sync word.
7	1	This frame is fill data.
8	1	This frame is the beginning of a subcom sequence.
9	0	This frame contains 1 kilobit real time data.
10	0	
9	1	This frame contains 8 kilobit real time data.
10	0	
9	0	This frame contains 64 kilobit real time data.
10	1	
9	1	This frame contains command storage playback data.
10	1	
11	1	This frame contains suspect data. This flag will appear when the bit errors in the frame sync word are ≥ 3 .
12	1	This frame contains corrected time.

* Computer determined.

** Bit 12 is most significant bit; bit one is least significant bit.

Figure 4-5. Decom Tape Format: Quality Status Fields

ATTITUDE TAPE

The Attitude Tape format is shown in Figures 4-6 and 4-7; Figure 4-8 defines the terminology used in the format definitions. The tape contains one file (a 250-word label record and 250-word data records) for each orbit. After the EOF following the last data record, there is a 250-word record of floating point nines (99999999.0), which is followed by an EOF.

Word	Units	Symbol	Function or Name	Description, Notes
1	none	ID	Identification	
2	year		Start time	Greenwich Mean Time
3	month		of orbit	(GMT); also called
4	day			Universal Time.
5	day	tE1	Eclipse start	Start time of eclipse in
6	msec. of day			GMT.
7	day	tE2	Eclipse end	End time of eclipse in
8	msec. of day			GMT.
9	day	tO1	Orbit start	Start time of orbit (time
10	msec. of day			of the ascending node). The ascending node is that point in the equatorial plane through which the satellite passes while going from south to north. See Figure 4-8 (c).
11	day	tO2	Orbit end	End time in GMT of this
12	msec. of day			orbit and start time of the next orbit (time of the next ascending node). See Figure 4-8 (c).

Figure 4-6. Attitude Tape Format: Label Record

Word	Units	Symbol	Function or Name	Description, Notes
13 14	day msec. of day	tn	Noon turn	Time in GMT of predicted noon turn. The paddles are only able to rotate through 180° . When the paddles are looking straight up ($\phi_p = 270^{\circ}$) or straight down ($\phi_p = 90^{\circ}$) at the sun, the spacecraft turns 180° about the body Z axis, so the paddle may reverse its direction of rotation and still continue to follow the sun. See data record word 121.
15 16	day msec. of day	τ	Epoch	The arbitrary reference time in GMT at which the orbital elements were computed.
17	msec.	Δt	Sampling rate	The values in the data records are given at intervals of $t_s + \Delta t$. The value of Δt is expected to be 60,000 milliseconds (1 min).
18	none		Orbit number	Orbit zero is from launch to the first ascending node. Orbit one starts at the first ascending node and ends at the second ascending node. The nth orbit starts at the nth ascending node. See Figure 4-8 (c).
19	earth radii	a	Semi-major axis	The semi-major axis of the orbital ellipse (1 earth radius = 6371.2 km). See Figure 4-8 (a).

Figure 4-6. Attitude Tape Format: Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
20	none	e	Eccentricity	The eccentricity of the orbital ellipse. See Figure 4-8 (a).
21	degrees	i	Inclination	The angle of the orbital plane and the earth's equatorial plane. See Figure 4-8 (b).
22	degrees	Ω	Longitude of ascending node	The angle between the Geocentric Equatorial Inertial (GEI) X axis (γ) and the position vector of the ascending node. See Figure 4-8 (d).
23	degrees / day	$\dot{\Omega}$		Rate of change of Ω .
24	degrees	ω	Argument of perigee	Perigee is that orbital point which is nearest the earth. ω is the angle between the position vector of the ascending node and the position vector of perigee. See Figure 4-8 (c).
25	degrees / day	$\dot{\omega}$		Rate of change of ω .
26	minutes	T	Period	The time required to make one orbit.
27	minutes / day	\dot{T}		Rate of change of T.
28-99				Spares

Figure 4-6. Attitude Tape Format Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
100	degree/sec.	r	Spin rate	If the spacecraft is spinning about an axis which is stabilized with respect to the craft, the spin rate, r , is given as a positive number.
101	degrees/ sec./day	\dot{r}		Rate of change of r .
102- 104	none	A	GEI spin axis	$A = (A_x, A_y, A_z)$ and is the spin axis as a unit vector in GEI coordinates A is defined so the spin rate, r , is positive with respect to the right-hand rule.
105- 107	none	A_b	Body spin axis	$A_b = (A_{bx}, A_{by}, A_{bz})$ is the spin axis as a unit vector represented in body coordinates. This representation will not change when the spin axis is stabilized with respect to the spacecraft.
108- 116	none	R_1	First spin matrix	In each of R_1, R_2 , and R_3 , the first three words contain the values in the top row of the matrix, the second three words contain the values in the middle row of the matrix,
117- 125		R_2	Second spin matrix	
126- 134		R_3	Third spin matrix	

Figure 4-6. Attitude Tape Format: Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
135- 250				<p>and the last three words contain the bottom row of the matrix.</p> <p>Let:</p> $b(T_1) = \begin{bmatrix} bXx & bYx & bZx \\ bXy & bYy & bZy \\ bXz & bYz & bZz \end{bmatrix}$ <p>where bXx through bZz are defined in data record words 49-57, i. e., bx, by, and bz at T_1 where T_1 is defined in word 1 of the data record. Now let $\bar{b}(T)$ be the interpolation of $b(T_1)$ to time T with no correction for spin.</p> <p>Then:</p> $\begin{aligned} b(T) &= \bar{b}(T) R1 + \bar{b}(T) R2 \sin \sigma (T) \\ &\quad + b(T) R2 \cos \sigma (T) \\ &= \bar{b}(T) R1 + R2 \sin \sigma (T) + R3 \\ &\quad \cos \sigma T \end{aligned}$ <p>where b(T) defines the body coordinate axes in GEI coordinates, as in $b(T_1)$, and $\sigma (T)$ is the angle from the spin vector $A(T_1) = (Ax, Ay, Az)$ at time T_1 to spin vector A(T) at time T.</p> <p>Spares</p>

Figure 4-6. Attitude Tape Format: Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
1	days	T ₁	Time	Day count.
2	msec.			Milliseconds of day in Greenwich Mean Time (GMT). All data in this record corresponds to T ₁ .
3	hours	TL	Local Time	Local Apparent Solar Time of subsatellite point.
4	minutes			
5	tenths of minutes			
6	degrees	α	Right ascension	The angle from the first point of Aries (γ) to the equatorial plane projection of the spacecraft position vector. See Figure 4-8 (e).
7	degrees	δ	Declination	The angle from the equatorial plane projection of the spacecraft position vector to the spacecraft position vector. See Figure 4-8 (e).
8-10	kilometers	P	Position vector	$P = (P_x, P_y, P_z)$ is the position vector of the spacecraft in Geocentric Equatorial Inertial (GEI) coordinates (also known as Universal coordinates). See Figure 4-8 (e).
11-13	kilometers/sec.	V	Velocity vector	$V = (V_x, V_y, V_z)$ is the direction and magnitude of the spacecraft velocity in GEI coordinates. See Figure 4-8 (e).
14-16	kilometers	S	Solar vector	$S = (S_x, S_y, S_z)$ is the position vector of the sun in GEI coordinates.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
17	degrees	ϕ	Latitude	Geodetic latitude of subsatellite point on the spheroid. North is +, South is -. The International Spheroid is used: a = semi-major axis = 6378.388 km f = flattening = 297. = a/a-b.
18	degrees	λ	Longitude	Geodetic longitude of subsatellite point on the spheroid. East is +, West is -.
19	kilometers	h	Height	Height of satellite above the spheroid. See Figure 4-8 (e).
20	degrees	ν	True anomaly	Orbital central angle between perigee and satellite with earth as focus. See Figure 4-8 (a).
21	degrees	Φ	Sun earth satellite angle	The angle between the satellite position vector and the sun position vector.
22-24	none	bXI	Ideal body roll axis	bXI = (bXI _x , bXI _y , bXI _z) is the ideal body X axis as a unit vector in GEI coordinates.
25-27	none	bYI	Ideal body pitch axis	bYI = (bYI _x , bYI _y , bYI _z) is the ideal body Y axis as a unit vector in GEI coordinates.
28-30	none	bZI	Ideal body yaw axis	bZI = (bZI _x , bZI _y , bZI _z) is the ideal body Z axis as a unit vector in GEI coordinates.
31-33	none	PXI	Ideal paddle roll axis	PXI = (PXI _x , PXI _y , PXI _z) is the paddle X axis as a unit vector in GEI coordinates.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
34-36	none	PYI	Ideal paddle pitch axis	$PYI = (PYIx, PYIy, PYIz)$ is the paddle Y axis as a unit vector in GEI coordinates.
37-39	none	PZI	Ideal paddle yaw axis	$PZI = (PZIx, PZIy, PZIz)$ is the paddle Z axis as a unit vector in GEI coordinates.
40-42	none	EXI	OPEP ideal roll axis	$EXI = (EXIx, EXIy, EXIz)$ is the OPEP X axis as a unit vector in GEI coordinates.
43-45	none	EYI	OPEP ideal pitch axis	$EYI = (EYIx, EYIy, EYIz)$ is the OPEP Y axis as a unit vector in GEI coordinates.
46-48	none	EZI	OPEP ideal yaw axis	$EZI = (EZIx, EZIy, EZIz)$ is the OPEP Z axis as a unit vector in GEI coordinates.
49-51	none	bX	Actual body roll axis	$bX = (bXx, bXy, bXz)$ is the body X axis as a unit vector in GEI coordinates.
52-54	none	bY	Actual body pitch axis	$bY = (bYx, bYy, bYz)$ is the body Y axis as a unit vector in GEI coordinates.
55-57	none	bZ	Actual body yaw axis	$bZ = (bZx, bZy, bZz)$ is the body Z axis as a unit vector in GEI coordinates.
58-60	none	PX	Actual paddle roll axis	$PX = (PXx, PXy, PXz)$ is the paddle X axis as a unit vector in GEI coordinates.
61-63	none	PY	Actual paddle pitch axis	$PY = (PYx, PYy, PYz)$ is the paddle Y axis as a unit vector in GEI coordinates.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
64-66	none	PZ	Actual paddle yaw axis	PZ = (PZx, PZy, PZz) is the paddle Z axis as a unit vector in GEI coordinates.
67-69	none	EX	Actual OPEP roll axis	EX = (EXx, EXy, EXz) is the OPEP X axis as a unit vector in GEI coordinates.
70-72	none	EY	Actual OPEP pitch axis	EY = (EYx, EYy, EYz) is the OPEP Y axis as a unit vector in GEI coordinates.
73-75	none	EZ	Actual OPEP yaw axis	EZ = (EZx, EZy, EZz) is the OPEP Z axis as a unit vector in GEI coordinates.
76	earth radii	R	Magnetic range	$R = L \cos^2(\phi_m)$ where L is the McIlwain parameter of the magnetic shell containing the spacecraft, and ϕ_m is the magnetic latitude of the spacecraft. Note that R is analogous to, but not equal to, $ P $, the magnitude of the position vector.
77	degrees	ϕ_m	Magnetic latitude	The latitude of the spacecraft in geomagnetic coordinates. At the magnetic equator $\phi_m = 0$. See Figure 4-8 (f).
78	earth radii	L	McIlwain parameter	A magnetic shell parameter which is almost constant along lines of force. L is used to label each shell. In the ideal case (dipole field), L is the magnitude of the position vector on the magnetic equator of the line of force. See Figure 4-8 (f).

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
79	gamma	B	Field strength	The magnitude of magnetic field strength at the spacecraft. See Figure 4-8 (c).
80	none	B/B_0	Ratio	B is defined above. B_0 is the equatorial field strength of the shell. See Figure 4-8 (f).
81	degrees	ϕI	Ingress latitude	The latitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft enters the earth. See Figure 4-8 (f).
82	degrees	λI	Ingress longitude	The longitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft enters the earth. See Figure 4-8 (f).
83	degrees	ϕE	Egress latitude	The latitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft leaves the earth. See Figure 4-8 (f).
84	degrees	λE	Egress longitude	The longitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft leaves the earth. See Figure 4-8 (f).
85-87	none	\hat{B}	B vector	$\hat{B} = (B_x, B_y, B_z)$ is the direction of the magnetic line of force expressed as a unit vector in the GEI system.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
88-90	none	Bb	B Body	$Bb = (Bbx, Bby, Bbz)$ is the unit direction vector, \hat{B} , expressed in the body coordinate system.
91-93	none	BP	B Paddle	$BP = (BPx, BPy, BPz)$ is the unit direction vector, \hat{B} , expressed in the paddle coordinate system.
94-96	none	BE	B OPEP	$BE = (BEx, BEy, BEz)$ is the unit direction vector, \hat{B} , expressed in the OPEP coordinate system.
97-99		$\hat{B}\hat{B}G$	$\hat{B}\hat{B}$ geodetic	BBG is the product of the field strength, B , times the unit vector, $\hat{B}G = (\hat{B}GE, \hat{B}GN, \hat{B}GV)$, where $(\hat{B}GE, \hat{B}GN, \hat{B}GV)$ is the unit vector, \hat{B} , expressed in geodetic coordinates. Note that this is a left-handed system instead of a right-handed system.
100-108	TGSE	GSE transformation		This is the transformation matrix which changes the GEI representation of a vector to GSE (Geocentric Solar Ecliptic) representation. The vector remains fixed. Words 100, 101, and 102 contain the values for the top row of the matrix, words 103, 104, and 105 contain the values for the middle row of the matrix, and words 106, 107, and 108 contain the values of the bottom row of the matrix.

Figure 4-7. Attitude Tape Format Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
109-117	none	TGSM	GSM transformation	<p>Any vector, v, in GEI is transformed by the relation</p> $V_{GSE} = (\text{matrix}) V_{GEI}$ $= TGSE V_{GEI}$ <p>This is the transformation matrix which changes the GEI representation of a vector to GSM (Geocentric Solar Magnetic) representation. The vector remains fixed. Words 109, 110, and 111 contain the top row of the matrix, words 112, 113, and 114 contain middle row of the matrix, and words 115, 116 and 117 contain the bottom row of the matrix.</p>
118-120	none	A	GEI spin axis	$A = (A_x, A_y, A_z)$ is the unit spin axis in GEI coordinates.
121		ϕ_P	Paddle angle	<p>The paddle shaft angle is $\phi_P = 90^\circ$ when the paddle is looking in the direction of the body +Z axis (toward earth), it is $\phi_P = 180^\circ$ when the paddle is looking in the -Y body axis direction (away from the OPEP), and $\phi_P = 270^\circ$ when the paddle is looking in the body -Z direction (away from the earth). Movement of the paddle is restricted such that $90^\circ \leq \phi_P \leq 180^\circ$.</p>

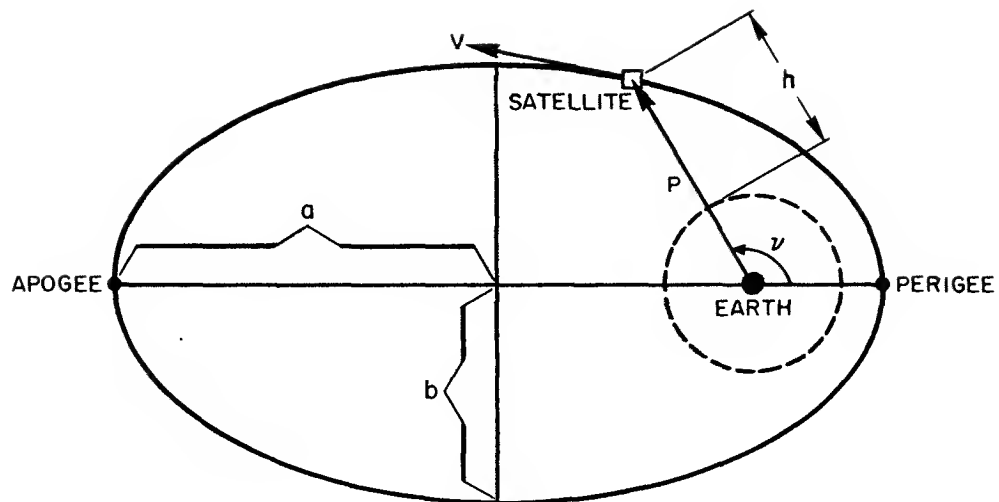
Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes																					
122	degrees	ψE	OPEP angle	The OPEP shaft angle is $\psi E = 0$ when the OPEP is looking in the body +X direction (away from the spacecraft), and $\psi E = 90^\circ$ when the OPEP is looking in the body +Y direction (away from the spacecraft), and $\psi E = 270^\circ$ when the OPEP is looking in the body -Y direction (looking over the spacecraft). The OPEP can rotate through more than 360° .																					
123	none	none	Attitude data flag	This flag is assigned the floating point value -1.0 if any housekeeping discrepancies are detected.																					
124		none	NO DATA flag	<p>A value of 2^k or any combination of $2^{k1} \cdot 2^{k2} \dots 2^{k5}$ in the NO DATA flag signifies that the data indicated by the flag was not available. The ideal value is used when the actual value is not available. The following table is used in words 124 and 125:</p> <table> <tr> <th>bit</th> <th>value</th> <th>data</th> </tr> <tr> <td></td> <td>2^0</td> <td>roll</td> </tr> <tr> <td></td> <td>2^1</td> <td>pitch</td> </tr> <tr> <td></td> <td>2^2</td> <td>yaw</td> </tr> <tr> <td></td> <td>2^3</td> <td>ψE = OPEP shaft angle</td> </tr> <tr> <td></td> <td>2^4</td> <td>ϕP = Paddle shaft angle</td> </tr> <tr> <td></td> <td>2^5</td> <td>Array error</td> </tr> </table>	bit	value	data		2^0	roll		2^1	pitch		2^2	yaw		2^3	ψE = OPEP shaft angle		2^4	ϕP = Paddle shaft angle		2^5	Array error
bit	value	data																							
	2^0	roll																							
	2^1	pitch																							
	2^2	yaw																							
	2^3	ψE = OPEP shaft angle																							
	2^4	ϕP = Paddle shaft angle																							
	2^5	Array error																							

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
125	none	none	SUSPECT DATA flag	(Note that word 124 is floating point.) This word warns that the indicated data is of a suspected nature. The indications are the same as for word 124.
126	none	T2	Time	$T2 = T1 + \Delta t$ and is defined the same as T1.
127-250	none			Defined the same as words 2-125 except that time T2 used.

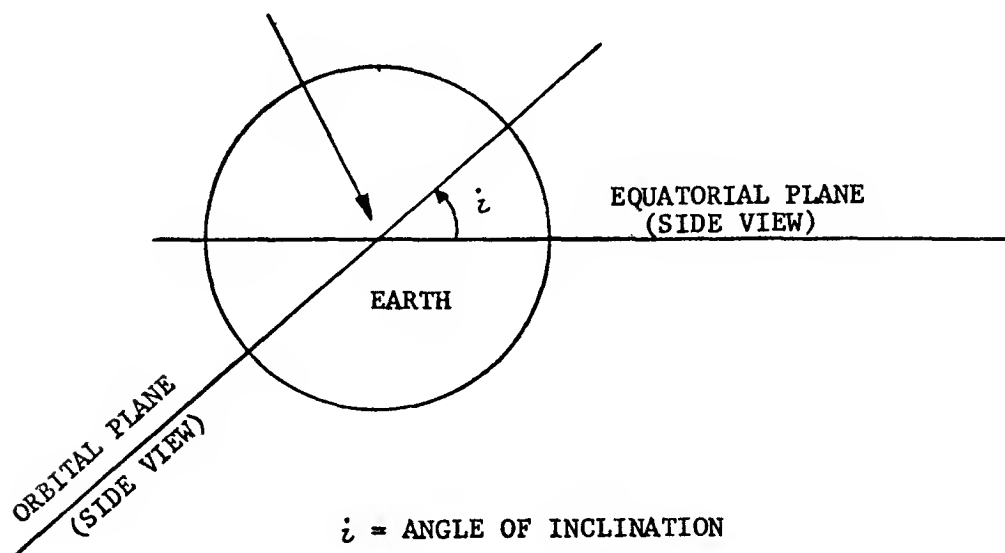
Figure 4-7. Attitude Tape Format: Data Record (continued)



$e = \sqrt{1 - b^2/a^2}$ = ECCENTRICITY
 a = SEMI-MAJOR AXIS
 b = SEMI-MINOR AXIS
 P = POSITION VECTOR
 v = VELOCITY VECTOR
 v = TRUE ANOMALY
 h = HEIGHT OF SATELLITE

(a)

ASCENDING AND DESCENDING NODES



(b)

Figure 4-8 (a) and (b). Attitude Tape Format: Definitions

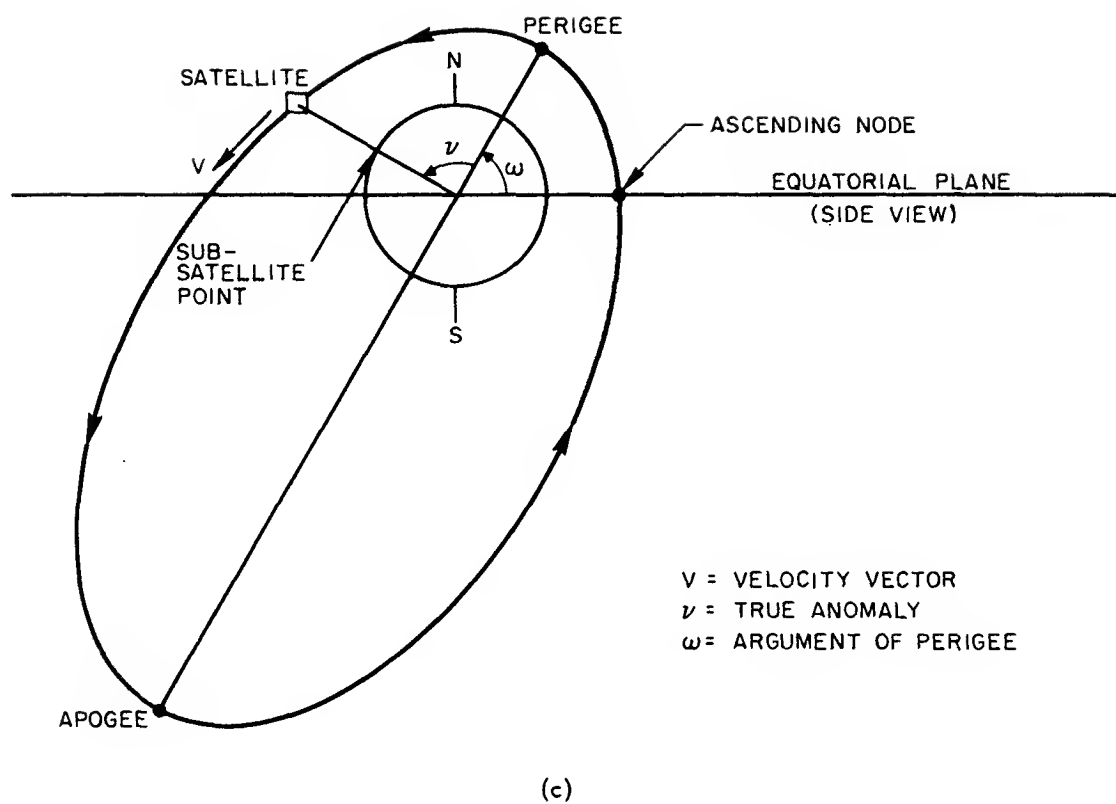
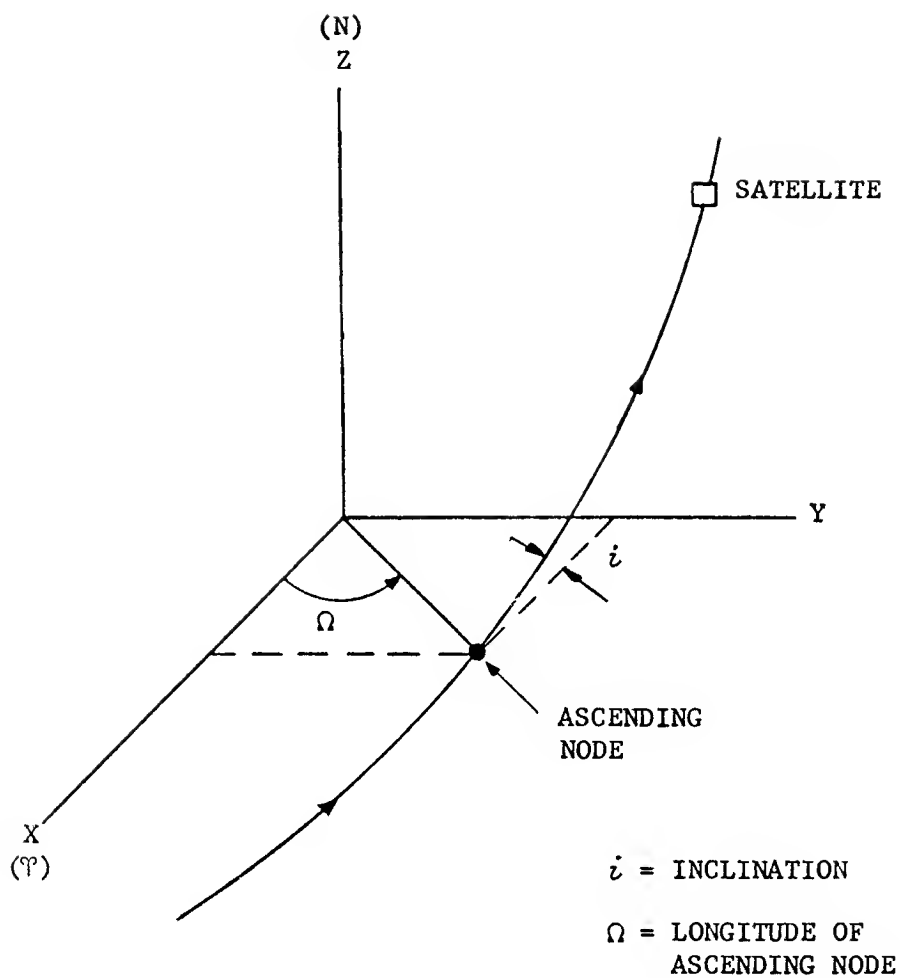


Figure 4-8 (c). Attitude Tape Format: Definitions

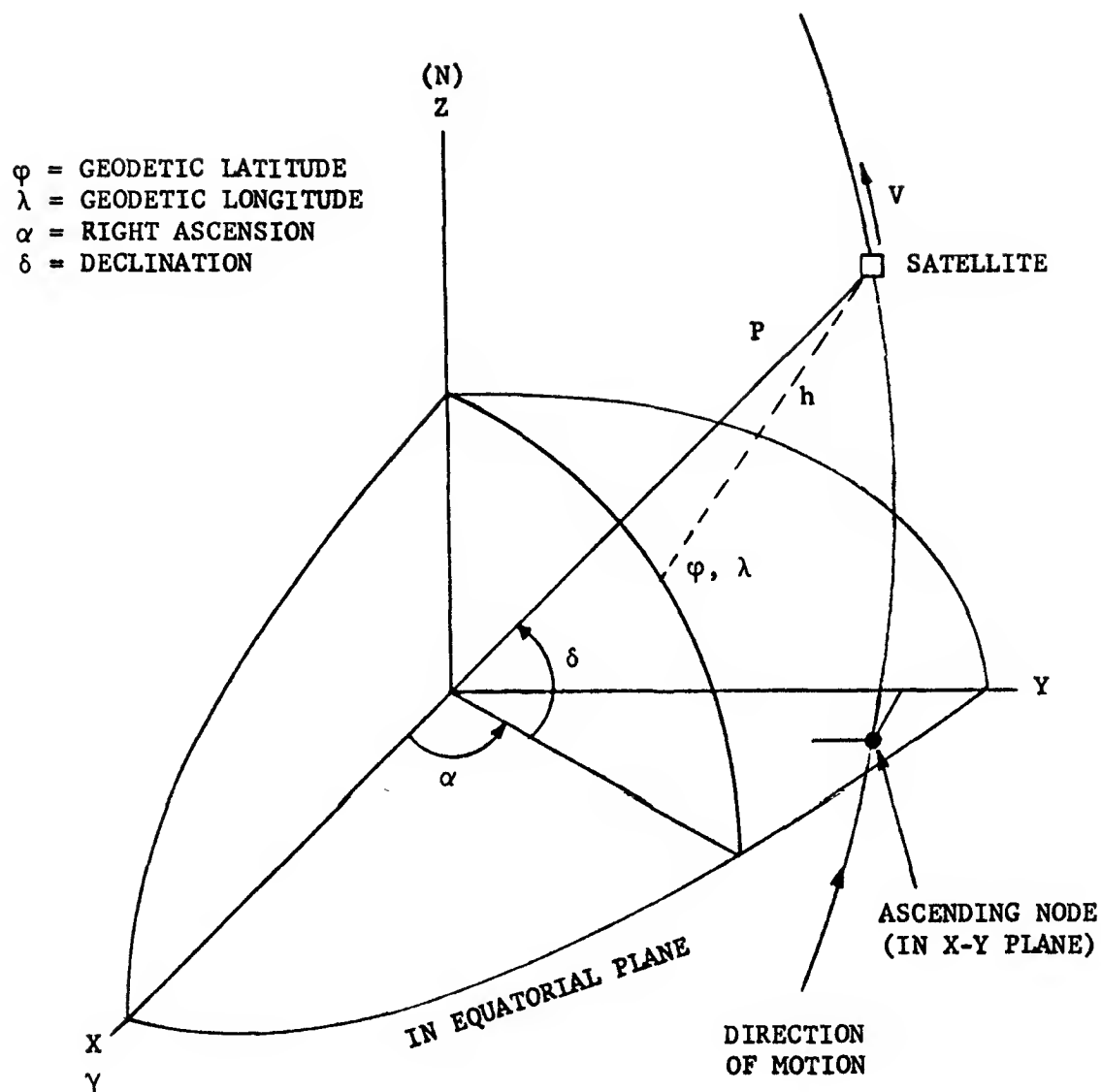


THE X-Y PLANE IS THE EQUATORIAL PLANE

NOTE THAT Ω IS FIXED FOR ANY GIVEN ORBIT
 (GEI COORDINATES)

(d)

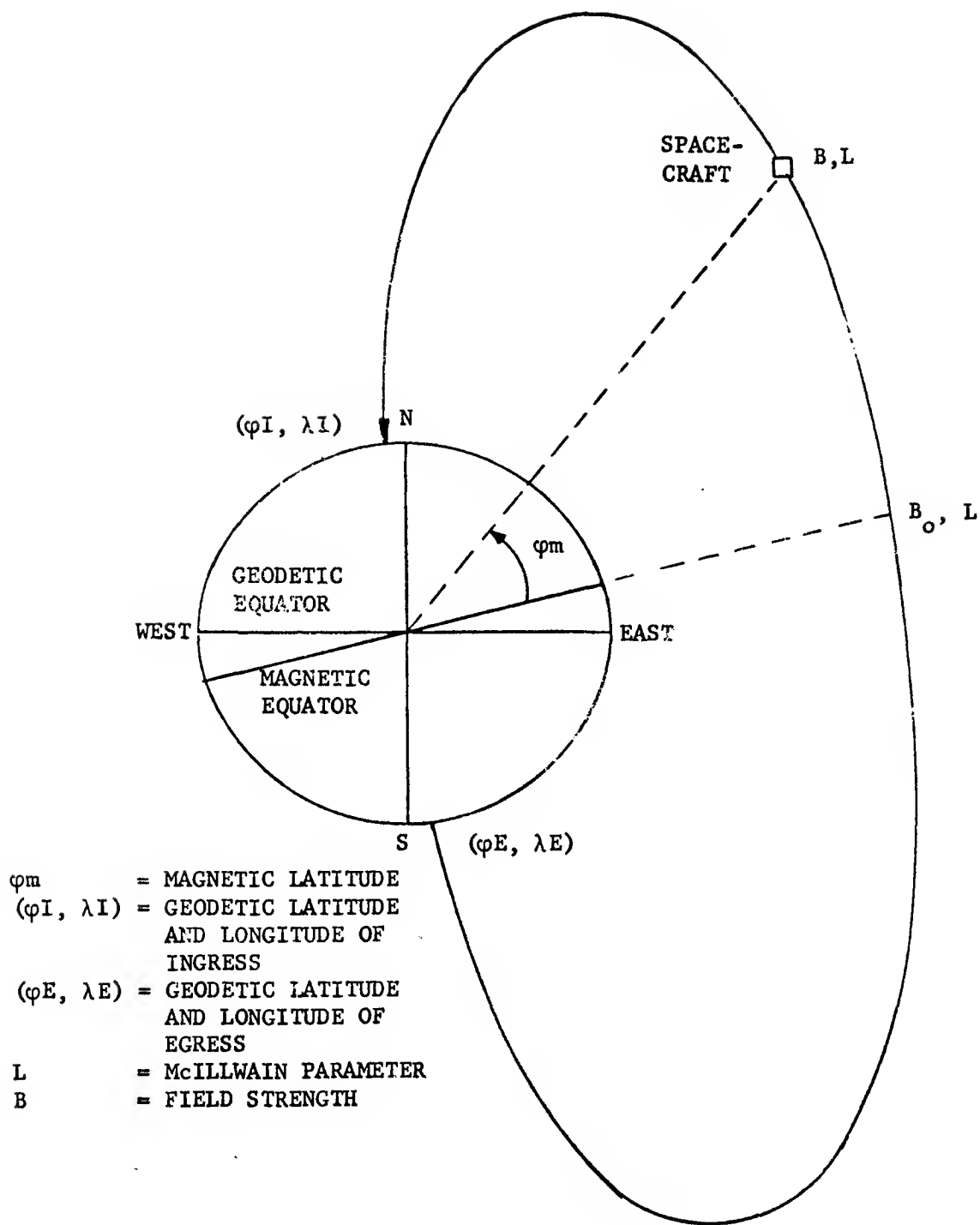
Figure 4-8 (d). Attitude Tape Format: Definitions



NOTE THAT α IS MEASURED FROM THE FIRST POINT ARIES (γ) WHICH IS FIXED, AND λ IS MEASURED FROM GREENWICH WHICH SPINS WITH THE EARTH.

(e)

Figure 4-8 (e). Attitude Tape Format: Definitions



(f)

Figure 4-8 (f). Attitude Tape Format: Definitions

GEGENSCHN DATA TAPES

The data tape contains five records per picture. The first record is a 412-character identification record. The remaining four records contain the picture data as shown in Figure 4-9.

	Word	Format	Contents
Identification Record - 412 Words	1	I	Begin time of picture (time of day).
	2	I	End time of picture (time of day).
	3	I	Time of yaw maneuver (day count of year).
	4	I	Time of yaw maneuver (time of day).
	5	I	Start time of eclipse (day count of year).
	6	I	Start time of eclipse (time of day).
	7	I	End time of eclipse (day count of year).
	8	I	End time of eclipse (time of day).
	9	I	Zero
	10	I	Accumulated satellite time.
	11	I	Temperature of SOEP Box #1 (-y) (raw value).
	12	I	Satellite identification.
	13	I	Year
	14	I	Station number.
	15	I	Analog tape number.
	16	I	Buffer tape number.
	17	I	Date of digitalization.
	18	I	Temperature of body package.
	19	I	Equipment group number.
	20	I	Binary tape number.
	21	I	Binary file number.
	22	I	Bit rate.
	23	I	Begin time of picture (day count of year).
	24	I	End time of picture (day count of year).

Figure 4-9. Gegenschein Data Tape Format

ID Record (continued)	25	I	Load bus voltage (raw value).
	26	FP	Yaw error (engineering units).
	27	FP	Array error (engineering units).
	28	FP	Temperature of SOEP Box #1 (-y) (engineering units).
	29	FP	Temperature of SOEP Box #1 (+y) (raw value).
	30	FP	Temperature of SOEP Box #1 (engineering units).
	31	FP	Temperature of Body Package (engineering units).
	32	I	Yaw error (raw value).
	33	FP	Load bus voltage (engineering units).
	34	FP	True anomaly.
	35	FP	Height.
	36	FP	Sun-earth-satellite angle.
	37-38		Zero
	39	I	Array error (raw value).
	40-45		Zero
	46-180	FP	Body attitude ($X_i, X_j, X_k, Y_i, Y_j, Y_k, Z_i, Z_j, Z_k$).
	181-315	FP	Paddle attitude ($X_i, X_j, X_k, Y_i, Y_j, Y_k, Z_i, Z_j, Z_k$).
	316-405	FP	Orbital positions (X, Y, Z), velocity (X, Y, Z).
	406-412		Zero
Data Record 1	1-704		Right ascension for 704 elements of the picture.
Data Record 2	1-704		Declination for 704 elements of the picture.
Data Record 3	1-704		Corrected intensities for 704 elements of the picture.
Data Record 4	1-704		Raw intensities for 704 elements of the picture.

Figure 4-9. Gegenschein Data Tape Format (continued)

TV TAPE FORMAT

Each file on the TV Tape consists of two records, a 120-character identification record and a 2816-word data record (Figure 4-10). The tape is low density, binary (odd parity) mode.

	Character	Contents
Identification Record (120 characters)	1-5+space	Satellite identification.
	7-8+space	Year.
	10-12+space	Station number.
	14-15+space	Analog file number.
	17-20+space	Analog tape number.
	22-23+space	Buffer file number.
	25-28+space	Buffer tape number.
	30-32+space	Date of digitalization (day of year).
	34-66+space	Identical to characters 1-33 unless errors were found in those characters, in which case this portion of the record will contain the corrected values.
	67+space	Type of data in the file: 0 = 1 kilobit realtime data 1 = 8 kilobit realtime data 2 = 64 kilobit realtime data 3 = command storage playback.
	69-77+space	Day of year, seconds of day, picture start time.
	79-90	Spare
	91-94+space	Master binary tape number.
	96-97	Master binary file number.
	98-120	Blank
Data Record (16896 characters)	1	Position of filter wheel.
	2	Data rate (1 or 8).
	3-2816	Elements of intensity per picture with the star background removed.
	(Words)	There are 704 elements; the intensity for each element is repeated four times (i. e., four values per element).

Figure 4-10. TV Tape Format

5. PROGRAM DESCRIPTIONS

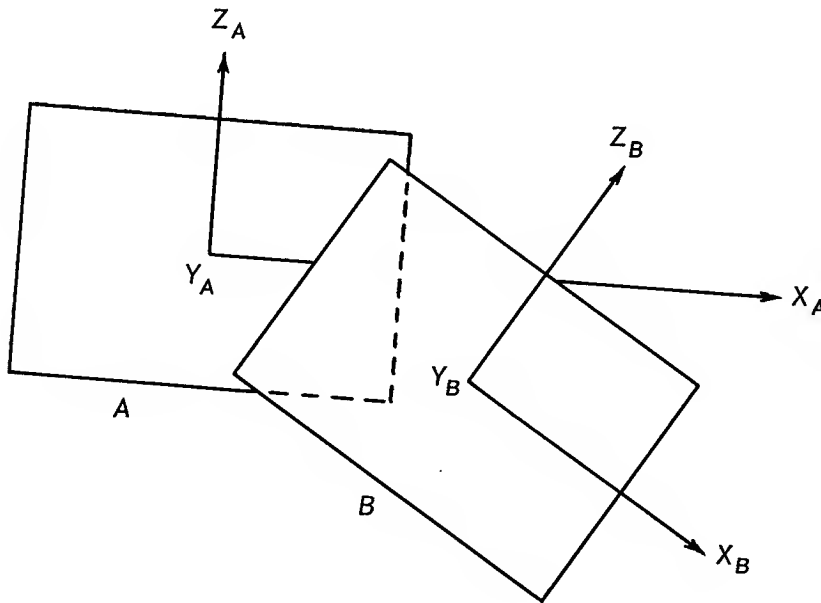
Gegenschein Processing Program

COMPUTATIONAL PROCEDURE

The data processing program associated with the gegenschein photometry experiment is used to re-create pictures taken of the sky. To attain this purpose, 11° by 16° anti-solar images of the sky are taken by an electronic camera of high photometric precision, mounted on a solar paddle of the satellite. The spherical surface subtended by the solid angle in question can be thought of as a rectangular array of elements or individual source areas having varying degrees of light intensity. The solid angle subtended by each elemental area, ΔA_{ij} , will be approximately $\frac{1}{2}^\circ$ and this matrix array will consist of 22 lines ($0 \leq i \leq 21$) and 32 elements per line ($0 \leq j \leq 31$) for a total of $ij = 704$ elements.

More specifically, it is required to obtain the coordinates of surface elements on the celestial sphere and the light intensities associated with these elements. The coordinates are expressed as right ascension and declination with respect to an inertial celestial reference system and then related to the celestial inertial ecliptic framework (Figure 5-1). The associated total light intensity that is photographed is later altered by the subtraction of the light intensity due to the starry background and the pre-flight calibrations of the tube sensitivity.

The purpose of the mathematics involved in determining the celestial coordinates of elemental areas can be shown by means of the visual interpretation:



where rectangle A is a representation of a picture at time t , and rectangle B is the picture at $t + \Delta t$.

During the time taken in scanning a picture, not only does the picture axis rotate but translation is also involved. Thus, picture orientation is dependent upon the motion of the solar paddle and spacecraft. Although the motion is small, we are dealing with elemental areas of $\frac{1}{2}^\circ \times \frac{1}{2}^\circ$.

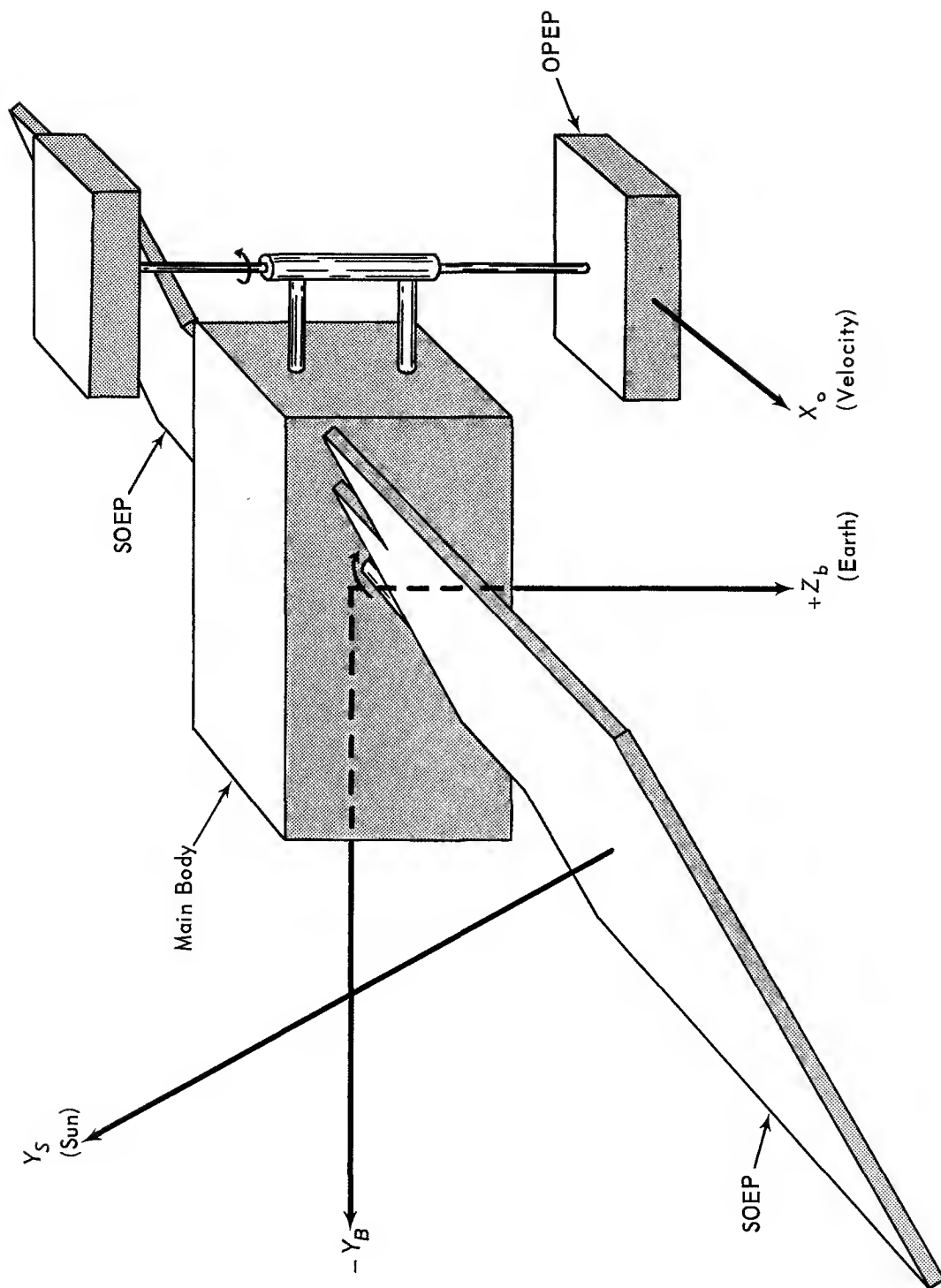


Figure 5-1

Nomenclature

- (X, Y, Z) = celestial orthogonal axes with origin at 0, the earth's center. X and Y lie in the earth's equatorial plane with X pointing to the first point of Aries.
- $(\bar{i}, \bar{j}, \bar{k})$ = unit vectors along the X, Y, Z axes respectively.
- (X_p, Y_p, Z_p) = right-handed orthogonal set of axes with origin, S , at the center of the satellite paddle. The X_p and Z_p axes lie in the solar face of the paddle and are coincident respectively with its longitudinal and transverse axes. The Y_p axis points in the direction of the sun.
- $(\hat{X}_p, \hat{Y}_p, \hat{Z}_p)$ = unit vectors along the X_p, Y_p, Z_p axes respectively.
- (X_g, Y_g, Z_g) = right-handed orthogonal set of axes with origin, S , at the center of both the picture and satellite paddle. The X_g and Z_g axes lie in the anti-solar face of the paddle and are coincident respectively with the longitudinal and transverse axes of both the paddle and picture. The Y_g axis is normal to the paddle and points in the anti-solar direction.
- $(\hat{X}_g, \hat{Y}_g, \hat{Z}_g)$ = unit vectors along the X_g, Y_g, Z_g axes respectively.
- (X'_g, Y'_g, Z'_g) = right-handed orthogonal set of axes with origin, S , at the center of the satellite paddle and Z'_g tangent to the meridian at this point and pointing in the direction of the celestial north pole. The Y'_g axis is normal to the paddle and points in the anti-solar direction.
- (X, Y_1, Z_1) = right-handed orthogonal axes with origin at 0, the earth's center. X and Y_1 lie in the ecliptic plane with X pointing to the first point of Aries.
- $(\bar{i}, \bar{j}_1, \bar{k}_1)$ = unit vectors along the X, Y_1, Z_1 axes respectively.
- α = right ascension in the (X, Y, Z) celestial inertial system.
- δ = declination in the (X, Y, Z) celestial inertial system.
- λ = right ascension in the inertial ecliptic (X, Y_1, Z_1) system.
- β = declination in the inertial ecliptic (X, Y_1, Z_1) system.
- B = orientation angle $Z_g S Z'_g$.
- (a, b, c) = direction angles in the X_p, Y_p, Z_p coordinate system.
- $(\bar{P}, \bar{Q}, \bar{R})$ = projections respectively of the unit vectors $\hat{X}_g, \hat{Y}_g, \hat{Z}_g$ on the XOY celestial equatorial plane.
- ΔA_{ij} = elemental area in the i th line and j th column of the picture.
- I''_{ij} = observed illumination intensity associated with elemental area ΔA_{ij} .
- I'_{ij} = intensity of illumination due to stars in the area ΔA_{ij} .
- I_{ij} = observed illumination intensity corrected for influence of stars in the elemental area ΔA_{ij} .
- $(\alpha_{ij}, \delta_{ij})$ = right ascension and declination of the center of the area ΔA_{ij} with respect to the XYZ system.

- ($\Delta \alpha'_{ij}$, $\Delta \delta'_{ij}$) = right ascension and declination corrections to be applied to the coordinates (α_{ij} , δ_{ij}) of the center of the picture because of improper mounting of the camera on the satellite paddle. Given by Solar Physics Branch.¹
- ($\Delta \alpha_{ij}$, $\Delta \delta_{ij}$) = right ascension and declination coordinates of ΔA_{ij} with respect to the center of picture. Given by Solar Physics Branch.

Determination of Celestial Coordinates of Elemental Areas

In Figure 5-2, (X, Y, Z) represent celestial orthogonal axes with their origin at 0, the earth's center. X and Y lie in the equatorial plane with X pointing to the first point of Aries. Z is perpendicular to the equatorial plane with the positive axis pointing toward the celestial north pole. Point C (X_c , Y_c , Z_c) is the geometric center of the lens of the camera mounted on the anti-solar axis of the paddle. CSY_g is the anti-solar axis of the paddle and OC is the position vector of the paddle. It is assumed that the camera axis is coincident with the paddle axis. In section 4, a method for correcting small differences which may exist between the two axes is described.

The celestial spherical surface *abcd* is the surface subtended by the 11° by 16° solid camera angle at C. The Z_g and X_g axes are coincident with the transverse and longitudinal axes of the picture. The right ascensions and declinations of OX_g , OY_g , OZ_g are given by αX_g , αY_g , αZ_g and δX_g , δY_g , δZ_g respectively.

The angle $B = Z'_g \angle Z_g$ is the orientation angle of the picture and is seen to be the angle between the transverse Z_g axis of the picture and the tangent to the meridian, Z_g , at the center of the picture.

The steps involved in the computation of the celestial right ascension and declination of an elemental picture area, ΔA_{ij} , are the following:

(a) Right Ascension and Declination of X_g , Y_g , Z_g Axes

From the Attitude-Orbit program, the functional relationship of unit vectors (\hat{X}_p , \hat{Y}_p , \hat{Z}_p) along the X_p , Y_p , Z_p paddle axes in terms of unit vectors (\bar{i} , \bar{j} , \bar{k}) along the X, Y, Z axes of the equatorial system are made available to us. Conveniently, the relationship of the G to P system is the following:
 $\hat{X}_g = -\hat{X}_p$, $\hat{Y}_g = -\hat{Y}_p$, and $\hat{Z}_g = \hat{Z}_p$

Since $\hat{\xi} = \cos a \xi \bar{i} + \cos b \xi \bar{j} + \cos c \xi \bar{k}$ ($\xi = X_p, Y_p, Z_p$)

$$\hat{X}_g = -\cos a X_p \bar{i} - \cos b X_p \bar{j} - \cos c X_p \bar{k} = \bar{P} - \cos c X_p \bar{k} \quad (1A)$$

$$\hat{Y}_g = -\cos a Y_p \bar{i} - \cos b Y_p \bar{j} - \cos c Y_p \bar{k} = \bar{Q} - \cos c Y_p \bar{k} \quad (1B)$$

$$\hat{Z}_g = \cos a Z_p \bar{i} + \cos b Z_p \bar{j} + \cos c Z_p \bar{k} = \bar{R} + \cos c Z_p \bar{k} \quad (1C)$$

$$\cos \alpha X_g = \bar{P} \cdot \bar{i} / |\bar{P}| = -\cos a X_p / (\cos^2 a X_p + \cos^2 b X_p)^{1/2} \quad (1)$$

$$\cos \alpha Y_g = \bar{Q} \cdot \bar{i} / |\bar{Q}| = -\cos a Y_p / (\cos^2 a Y_p + \cos^2 b Y_p)^{1/2} \quad (2)$$

$$\cos \alpha Z_g = \bar{R} \cdot \bar{i} / |\bar{R}| = \cos a Z_p / (\cos^2 a Z_p + \cos^2 b Z_p)^{1/2} \quad (3)$$

¹Dr. Charles Wolff, Solar Physics Branch, Code 614; GSFC, Greenbelt, Maryland 20771.

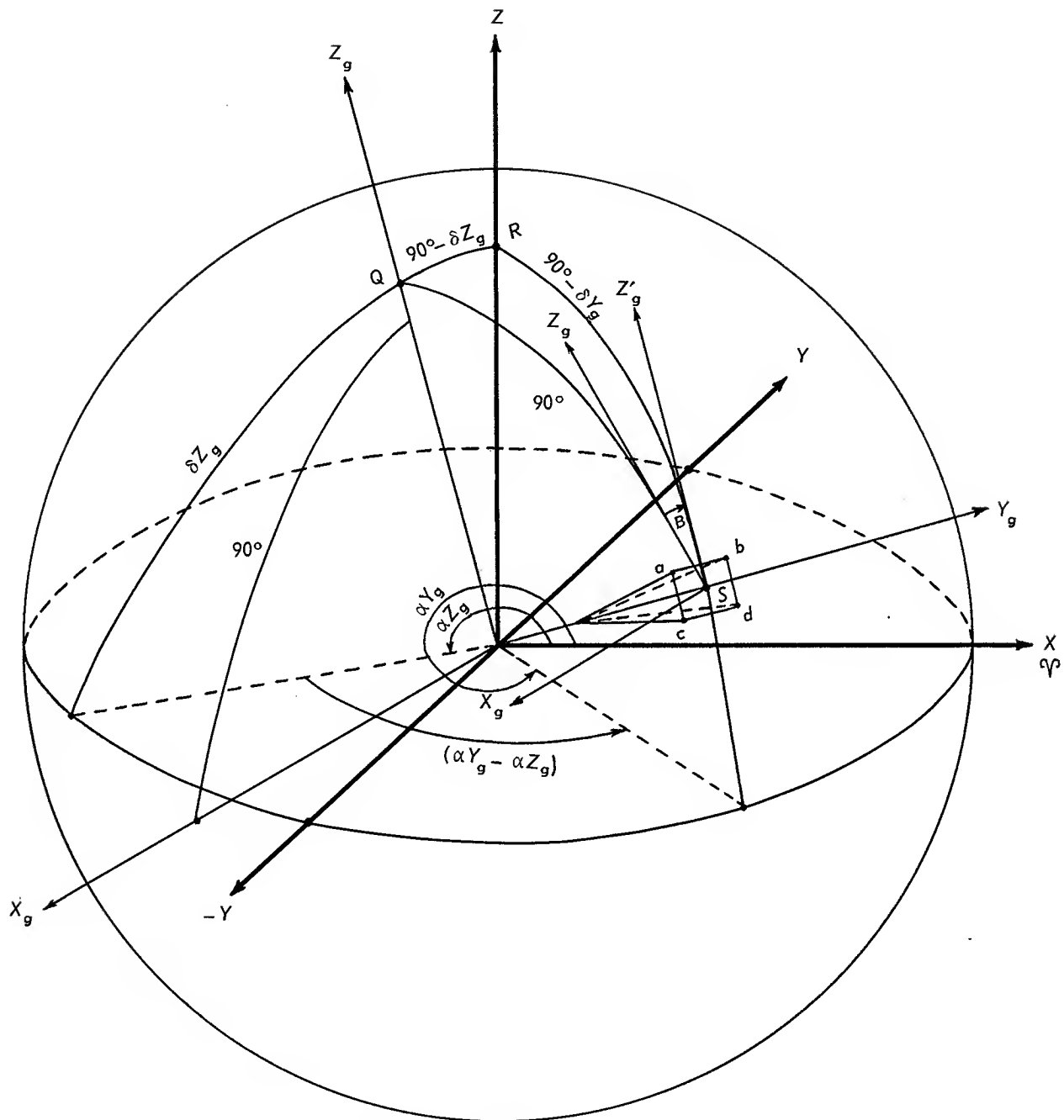


Figure 5-2—Celestial Coordinate System

$$\sin \delta X_g = \hat{X}_g \cdot \bar{k} = -\cos c X_p \quad (4)$$

$$\sin \delta Y_g = \hat{Y}_g \cdot \bar{k} = -\cos c Y_p \quad (5)$$

$$\sin \delta Z_g = \hat{Z}_g \cdot \bar{k} = \cos c Z_p \quad (6)$$

$$\hat{X}_g = -X' \bar{i} - Y' \bar{j} - Z' \bar{k}$$

$$\hat{Y}_g = -X'' \bar{i} - Y'' \bar{j} - Z'' \bar{k}$$

$$\hat{Z}_g = X''' \bar{i} + Y''' \bar{j} + Z''' \bar{k}$$

$$[(X')^2 + (Y')^2 + (Z')^2]^{1/2} = 1 \quad (7)$$

where:

$$X' = \cos a X_p$$

$$Y' = \cos b X_p \quad (8)$$

$$Z' = \cos c X_p$$

$$X'' = \cos a Y_p \quad (9)$$

etc.

(b) Smoothing Program

In the computations associated with the objective stated above, the right ascension and declination of the X_g and Y_g axes are required as continuous functions of time. As can be seen from an inspection of equations (2), (3), (5), and (6), this involves the smoothing of the six components of equations (1B) and (1C).

During a picture sequence, each of the six variables have up to 15 values depending upon the satellite data rate. These data points are smoothed to a quadratic approximating function in time using a least squares technique.

(c) Determination of Orientation Angle B

In the spherical triangle QRS of Figure 5-2, the angle between tangents to the great circle arcs $(90^\circ - \delta Z_g)$ and $(90^\circ - \delta Y_g)$ at the point R has the magnitude $(\alpha Y_g - \alpha Z_g)$. The angle B is the included angle between SZ'_g and SZ_g . At the point S, SZ_g is tangent to the 90° great circle arc between Z_g and Y_g axes and SZ'_g is tangent to the $(90^\circ - \delta Y_g)$ great circle arc. Angles $ZOZ_g = (90^\circ - \delta Z_g)$ and $Y_g OZ_g = 90^\circ$; therefore:

$$\begin{aligned} \sin B &= \sin (90^\circ - \delta Z_g) \sin (\alpha Y_g - \alpha Z_g) / \sin 90^\circ \\ &= \cos \delta Z_g \sin (\alpha Y_g - \alpha Z_g) \\ &= \cos \delta Z_g [\sin \alpha Y_g \cos \alpha Z_g - \cos \alpha Y_g \sin \alpha Z_g] \end{aligned} \quad (10)$$

(d) Determination of Celestial Right Ascension and Declination

At this point, we have the right ascension and declination of the Y_g and Z_g axes as continuous functions of time. Since the angle B is a function of these variables, it can be evaluated at any time instant.

As the satellite orbits, the instantaneous position of the center of the picture can be determined by evaluating $Y_g = f(t)$ and $\delta Y_g = h(t)$ at the moment t_{ij} corresponding to the event ΔA_{ij} . In this connection, it is assumed that the camera axis is mounted coincidentally with the paddle axis OY_g . In the event this condition does not prevail, corrections ($\Delta \alpha'_{ij}$, $\Delta \delta'_{ij}$) will be added in the determination of α_{ij} , δ_{ij} of the area ΔA_{ij} . The development follows:

$$X'_g = X_g \cos B - Z_g \sin B \quad (11)$$

$$Z'_g = Z_g \sin B - Z_g \cos B \quad (12)$$

Figure 5-3 is a representation of conditions in the tangent plane at S at $t = t_{ij}$. The coordinates X_g , Z_g are furnished by the Solar Physics Branch for each element of the picture.

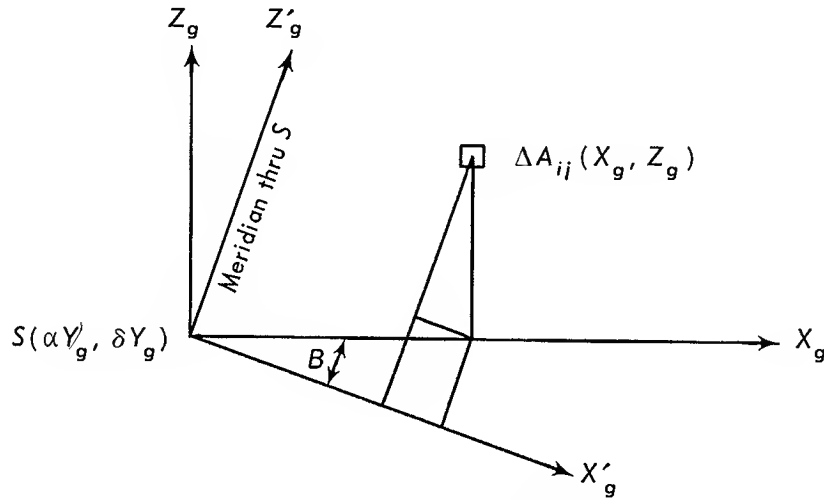


Figure 5-3—Tangent Plane

On the basis of the foregoing and in view of Figure 5-4, the right ascension and declination of ΔA_{ij} are:

$$\alpha_{ij} = \alpha Y_g + \Delta \alpha_{ij} + \Delta \alpha'_{ij} \quad (13)$$

$$\delta_{ij} = \delta Y_g + \Delta \delta_{ij} + \Delta \delta'_{ij}$$

where $\Delta \alpha_{ij}$ and $\Delta \delta_{ij}$ have the following definitions:

$$\Delta \delta_{ij} = Z'_g \quad (14)$$

$$X'_g = \cos [(\delta Y_g + \Delta \delta'_{ij}) + \Delta \delta_{ij}] \cdot \Delta \alpha_{ij} \quad (15)$$

$$\Delta \alpha_{ij} = \frac{X'_g}{\cos [(\delta Y_g + \Delta \delta'_{ij}) + \Delta \delta_{ij}]} \quad (16)$$

and $\Delta \alpha'_{ij} + \Delta \delta'_{ij}$ are corrections based upon the mounting of the camera on the solar paddle.

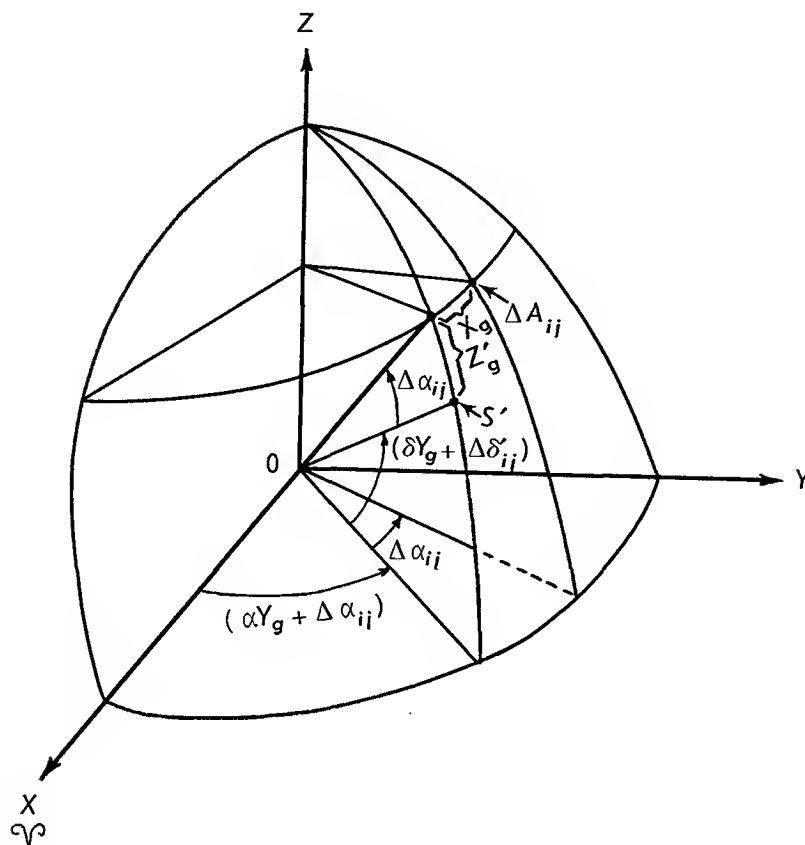


Figure 5-4—Relationship of Individual Picture Elements to Celestial Coordinate System

Corrections Caused by Starry Background

Each picture of the sky can be considered to be a matrix array of i lines and j columns of elemental areas, ΔA_{ij} . As stated previously in section 1 above, associated with the center of each ΔA_{ij} , there is a couplet $(\alpha_{ij}, \delta_{ij})$, associated with the time of the event $t = t_{ij}$.

The observed illumination intensities I''_{ij} , associated with the elemental areas ΔA_{ij} , are obtained from the picture. The α and δ bounds of the square element at area, ΔA_{ij} , having an area of $4R^2$, are given by $(\alpha_{ij} \pm R)$ and $(\delta_{ij} \pm R)$. Due to the limited resolving power of the camera, it is believed that, in reality, each ΔA_{ij} can be considered a circle having a radius R of approximately 0.35° .

The influence of the illumination of the stars, I'_{ij} , can be eliminated by using the equation $I_{ij} = I''_{ij} - I'_{ij}$. To accomplish this correction, the following steps are important:

(1) The intensities of all stars, I'_{ij} , with their corresponding α_{ij} and δ_{ij} values to the nearest $.01^\circ$, are stored in computer memory.

(2) The ij observed illumination intensities I''_{ij} with their relevant α_{ij} and δ_{ij} values to the nearest $.01^\circ$ are stored in memory for each picture.

(3) For each element of (2), the star table is searched to see if any star lies within $(\alpha_{ij} \pm R, \delta_{ij} \pm R)$. If so, star intensity I'_{ij} is subtracted.

Conversion of Celestial Equatorial Coordinates to Ecliptic Longitude and Latitude

Before print out, the celestial equatorial right ascension and declination coordinates $(\alpha_{ij}, \delta_{ij})$ of ΔA_{ij} are converted to ecliptic longitude and latitude $(\lambda_{ij}, \beta_{ij})$. The conversion relationships appear at the end of this section.

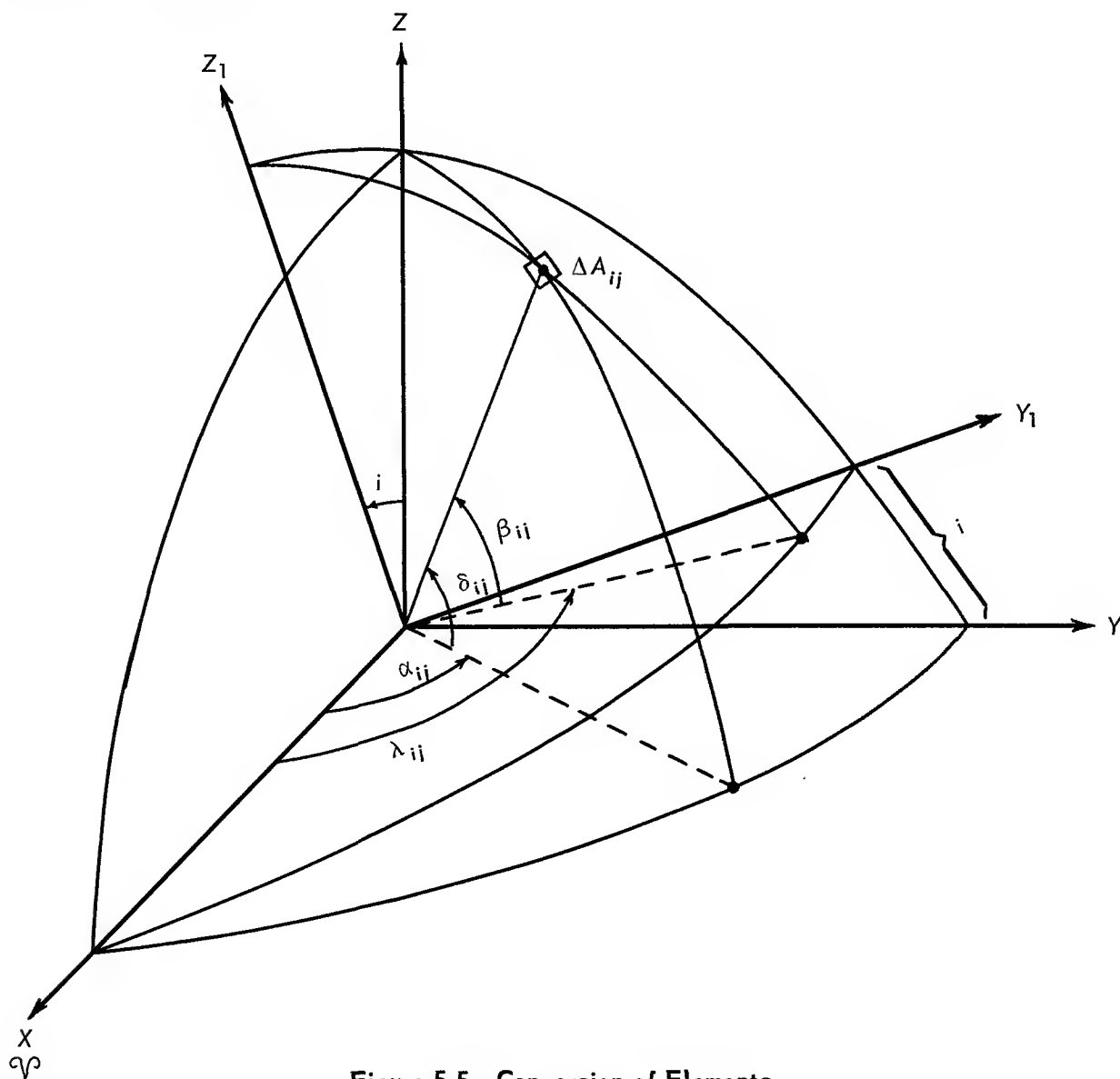


Figure 5-5—Conversion of Elements

In Figure 5-5, XOY is the celestial equatorial plane and $Z_1 OY_1$ is the ecliptic plane oriented at an inclination angle i of approximately 23.5° . The coordinates α_{ij} and δ_{ij} of ΔA_{ij} are given. It is required to find λ_{ij} and β_{ij} .

If rectangular coordinates are used, it will be observed that only the Y and Z coordinates change. The X axis is common to both systems. If the point P(Y, Z) is the projection of the center of ΔA_{ij} on the YOZ plane, we have the condition shown in Figure 5-6.

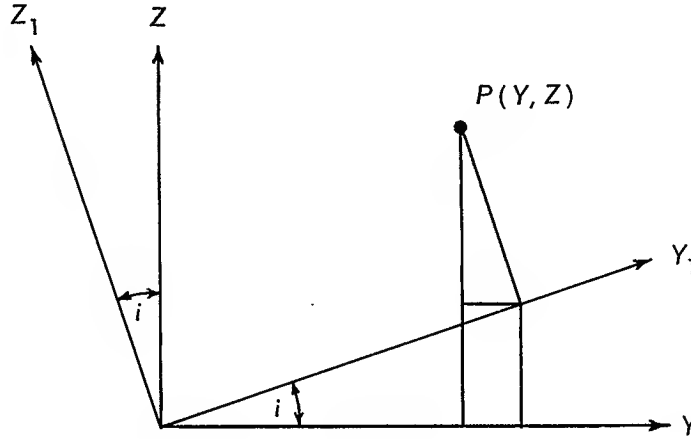


Figure 5-6—Rectangular Coordinates

$$\begin{aligned} Y &= Y_1 \cos i - Z_1 \sin i & \bar{j} &= \bar{j}_1 \cos i - \bar{k}_1 \sin i \\ Z &= Y_1 \sin i + Z_1 \cos i & \bar{k} &= \bar{j}_1 \sin i + \bar{k}_1 \cos i \end{aligned} \quad (18)$$

Let \bar{r} be a unit vector along the line connecting the origin of Figure 5-5 with the center of ΔA_{ij} ; then:

$$\bar{r} = X_{ij} \bar{i} + Y_{ij} \bar{j} + Z_{ij} \bar{k} \quad (19)$$

$$\bar{r} \cdot \bar{r} = X_{ij}^2 + Y_{ij}^2 + Z_{ij}^2 = 1 \quad (20)$$

In equation 20, X_{ij} , Y_{ij} , Z_{ij} can be thought of as the directional cosines with respect to the XYZ system of the line joining the origin of Figure 5-5 with the point $(\alpha_{ij}, \delta_{ij})$; consequently,

$$\sin \delta_{ij} = \bar{r} \cdot \bar{k} = Z_{ij} \quad (21)$$

In equation 21, Z_{ij} can be evaluated since δ_{ij} is known. An asterisk in the following will be an indication of known quantities.

$$\cos \alpha_{ij}^* = (X_{ij} \bar{i} + Y_{ij} \bar{j}) \cdot \bar{i} = X_{ij} / (X_{ij}^2 + Y_{ij}^2)^{1/2} \quad (22)$$

$$X_{ij}^2 = (X_{ij}^2 + Y_{ij}^2) (\cos \alpha_{ij}^*) \quad (23)$$

$$\text{From (20):} \quad (X_{ij}^2 + Y_{ij}^2) = 1 - (Z_{ij}^*)^2 \quad (24)$$

$$\text{Therefore:} \quad X_{ij} = \pm \sqrt{[1 - (Z_{ij}^*)^2] (\cos^2 \alpha_{ij}^*)} \quad (25)$$

Y_{ij} can be evaluated from equation (20) since both X_{ij} and Y_{ij} have now been determined.

Using equations (18) and (19), \bar{r} can be expressed with respect to unit vectors along the axes of the ecliptic (XY_1Z_1) system.

$$\bar{r} = X_{ij}\bar{i} + Y_{ij}(\cos i\bar{j}_1 - \sin i\bar{k}_1) + Z_{ij}(\sin i\bar{j}_1 + \cos i\bar{k}_1) \quad (26)$$

$$\bar{r} = X_{ij}\bar{i} + (Y_{ij} \cos i + Z_{ij} \sin i)\bar{j}_1 + (Z_{ij} \cos i - Y_{ij} \sin i)\bar{k}_1 \quad (27)$$

$$\sin \beta_{ij} = \bar{r} \cdot \bar{k}_1 = Z_{ij} \cos i - Y_{ij} \sin i \quad (28)$$

$$\cos \lambda_{ij} = \frac{[X_{ij}\bar{i} (Y_{ij} \cos i + Z_{ij} \sin i)\bar{j}_1] \cdot \bar{i}}{[X_{ij}^2 + (Y_{ij} \cos i + Z_{ij} \sin i)^2]^{1/2}} \quad (29)$$

$$\cos \lambda_{ij} = \frac{X_{ij}}{[X_{ij}^2 + (Y_{ij} \cos i + Z_{ij} \sin i)^2]^{1/2}} \quad (30)$$

$$\text{On a unit sphere:} \quad X_{ij} = \cos \delta_{ij} \cos \alpha_{ij} \quad (31)$$

$$Y_{ij} = \cos \delta_{ij} \sin \alpha_{ij} \quad (32)$$

$$Z_{ij} = \sin \delta_{ij}$$

$$\text{Therefore:} \quad \sin \beta_{ij} = \sin \delta_{ij} \cos i - \cos \delta_{ij} \sin \alpha_{ij} \sin i \quad (33)$$

$$\cos \lambda_{ij} = \frac{\cos \delta_{ij} \cos \alpha_{ij}}{[\cos^2 \delta_{ij} \cos^2 \alpha_{ij} + (\cos \delta_{ij} \sin \alpha_{ij} \sin i + \sin \delta_{ij} \sin i)^2]^{1/2}} \quad (34)$$

Least Squares Technique

When the time dependent variable $X = X(T)$ is given and a quadratic fit is required such that $X = A + BT + CT^2$, the applicable least squares normal equations and their solutions for the determination of the coefficients in terms of n sets of (T_i, X_i) values are:

$$\sum_{i=1}^n x_i = n a + b \sum_{i=1}^n t_i + c \sum_{i=1}^n t_i^2 \quad \text{where } n \geq 5 \quad (1)$$

$$\sum_{i=1}^n x_i t_i = a \sum_{i=1}^n t_i + b \sum_{i=1}^n t_i^2 + c \sum_{i=1}^n t_i^3 \quad (2)$$

$$\sum_{i=1}^n x_i t_i^2 = a \sum_{i=1}^n t_i^2 + b \sum_{i=1}^n t_i^3 + c \sum_{i=1}^n t_i^4 \quad (3)$$

$$\sum_{i=1}^n x_i = V_0 \quad \sum_{i=1}^n x_i t_i = V_1 \quad \sum_{i=1}^n x_i t_i^2 = V_2$$

$$n = S_0 \quad \sum_{i=1}^n t_i = S_1 \quad \sum_{i=1}^n t_i^2 = S_2 \quad \sum_{i=1}^n t_i^3 = S_3 \quad \sum_{i=1}^n t_i^4 = S_4$$

$$a + \beta_{12} b + \beta_{13} c = \beta_{14} \quad (4)$$

$$\beta_{22} b + \beta_{23} c = \beta_{24} \quad (5)$$

$$\beta_{32} b + \beta_{33} c = \beta_{34} \quad (6)$$

where:

$$\beta_{12} = S_1 / S_0 \quad \beta_{13} = S_2 / S_0 \quad \beta_{14} = V_0 / S_0$$

$$\beta_{22} = S_2 - \beta_{12} S_1 \quad \beta_{23} = S_3 - \beta_{13} S_1 \quad \beta_{24} = V_1 - \beta_{14} S_1$$

$$\beta_{32} = S_3 - \beta_{12} S_2 \quad \beta_{33} = S_4 - \beta_{13} S_2 \quad \beta_{34} = V_2 - \beta_{14} S_2$$

$$b + K_{23} c = K_{24} \quad (7)$$

$$K_{33} c = K_{34} \quad (8)$$

where:

$$K_{23} = \beta_{23} / \beta_{22} \quad K_{24} = \beta_{24} / \beta_{22}$$

$$K_{33} = \beta_{33} - K_{23} \beta_{32} \quad K_{34} = \beta_{34} - K_{24} \beta_{32}$$

$$\text{From (8):} \quad c = K_{34} / K_{33} \quad (9)$$

$$\text{From (7):} \quad b = K_{24} - (K_{23}) c \quad (10)$$

$$\text{From (4):} \quad a = \beta_{14} - (\beta_{12}) b - (\beta_{13}) c \quad (11)$$

SUBROUTINE DESCRIPTIONS AND FLOWCHARTS

Name	Code	Description
EGO20	Sleuth II	Main Program - Experiment #20
RD	Sleuth II	Reads BOSS and Circular Arc Data.
TESTD	Sleuth II	Searches DECOM tape for starting point of good data.
FNDTIM	Sleuth II	Computes picture start and end time.
CKROUT	Sleuth II	Data handling and checking routine.
TVTAPE	Sleuth II	Writes TV output tape.
STARRY	Sleuth II	Subtracts Starry Background intensities.
DECID	Sleuth II	Reads DECOM ID from tape.
DECDAT	Sleuth II	Reads DECOM data from tape.
ASPID	Sleuth II	Reads Attitude ID from tape.
ASPDAT	Sleuth II	Reads Attitude data from tape.
LSQS	Fortran IV	Least Squares Quadratic Solution and computation of attitude elements.
ROTATE	Fortran IV	Rotates RA and DEC for every picture element into ecliptic coordinates.
OUTPUT	Fortran IV	Writes output on HSP and tape.

EXEC II Library

EBCDB\$	KTYPE\$	TEF\$
MERR\$	PRINT\$	TRF\$
MEXIT\$		TRI\$
MVFY1\$		TPE\$
MVFY2\$		TPB\$
		TSWAP\$
		TWR\$

Function

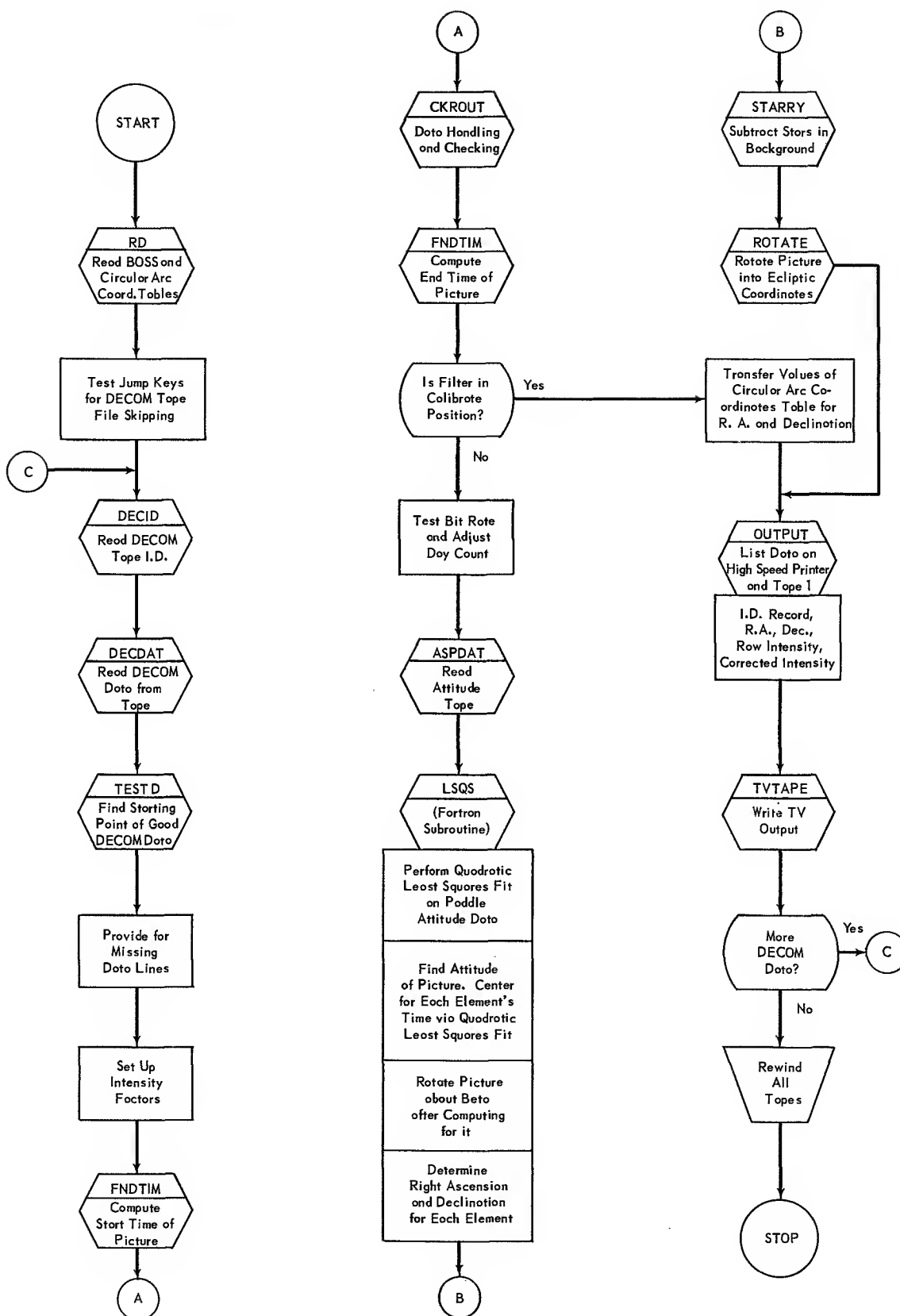
This is the main routine for the GEGENSCHN Processing Program. It calls the major READ, COMPUTE and WRITE routines, handles major loop control, and handles finalization.

Calling Sequence

None

Operational Description

1. Reads BOSS and Circular Arc Coordinates tables.
2. Skip Decom input files under jump key control.
3. Reads Decom tape.
4. Locates starting point of "good" Decom data.
5. Edits data and provides missing data items.
6. Accommodates filter wheel position and bit rate.
7. Reads Attitude (aspect) tape.
8. Performs quadratic least squares fit on paddle and attitude data.
9. Rotates picture and determines RA and DEC for each of the 704 picture elements.
10. Subtracts starry background.
11. Rotates picture into ecliptic coordinates.
12. Outputs data to high speed printer and tape.
13. Writes TV tape output.
14. Loops back if more Decom data.
15. Finalization when no more Decom data.



RD (Sleuth II)

Function

Reads BOSS and circular arc table data.

Calling Sequence

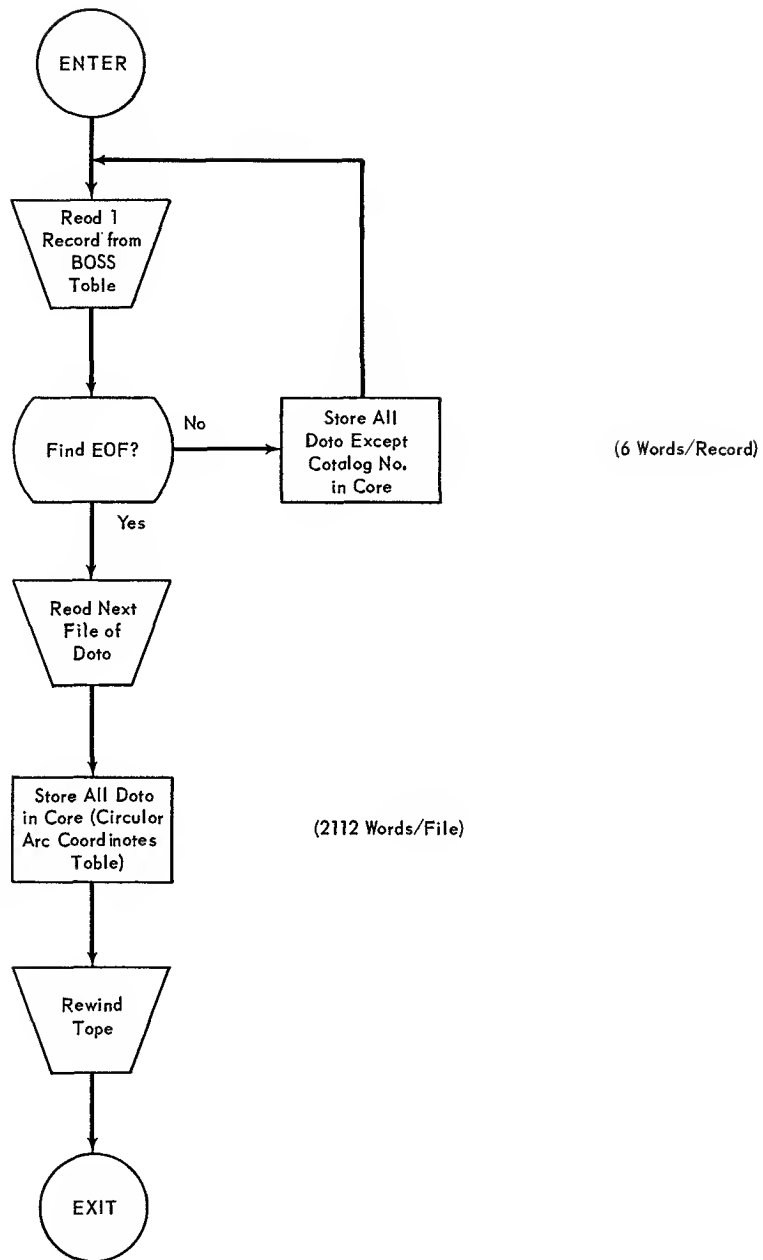
In-line code

Operational Description

1. Read BOSS table records into core (6 words/record).
2. Read Circular Arc Coordinates table into core (2112 words/file).
3. Rewind tape I.
4. Continue.

Programs Used

MV FY1\$
MV FY2\$
TRF\$
TRI\$



TESTD (Sleuth II)

Function

Searches DECOM tape for starting point of good data.

Calling Sequence

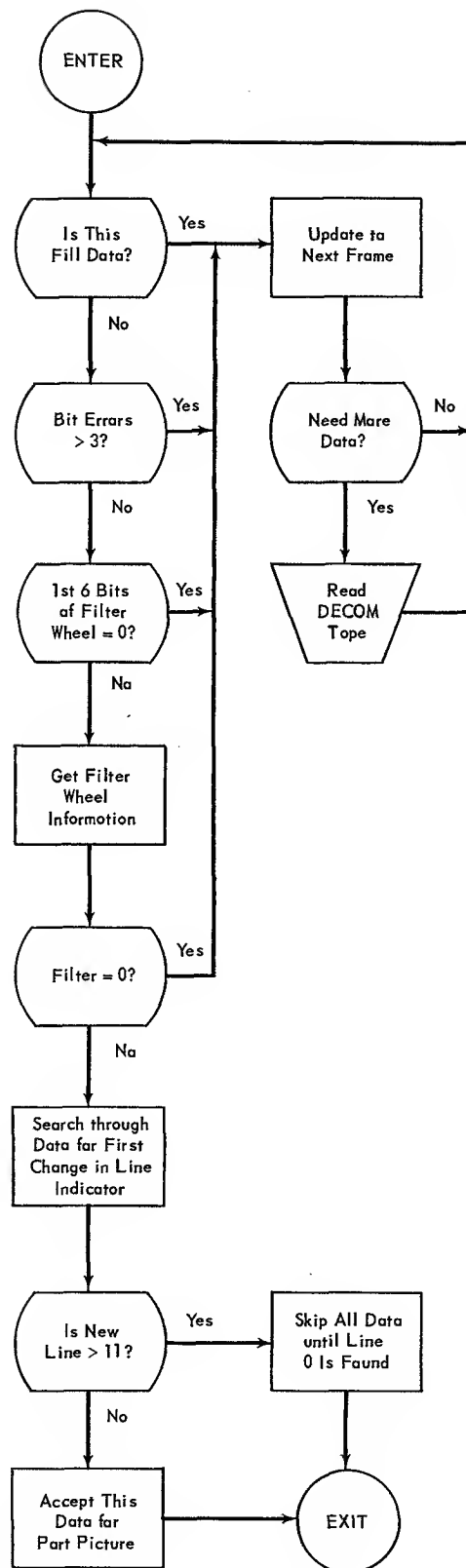
In-line code.

Operational Description

1. Test for fill data.
2. Test for bit errors.
3. Test filter wheel position.
4. Search for change in line indicator.
5. If line indicator is higher than 11, skip data until line zero is found.
6. Accept data for part picture.
7. Continue.

Programs Used

DECDAT
ASPID



FNDTIM (Sleuth II)

Function

Computes picture start or end time.

Calling Sequence

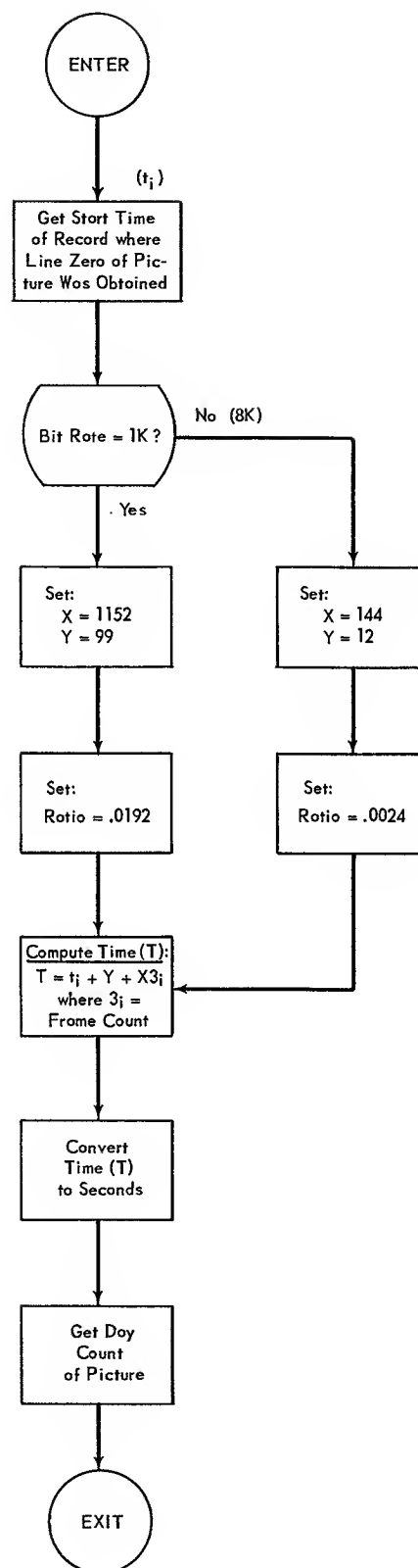
SLJ FNDTIM

Operational Description

1. Pick up start time of line zero.
2. Test kilobit rate and set x, y and RATIO.
3. Compute TIME and convert to seconds.
4. Get day count of picture.
5. Exit.

Programs Used

None



CKROUT (Sleuth II)

Function

Data Handling and Checking Routine

Calling Sequence

In-line code

Operational Description

1. Pick up data frame.
2. Check status.
3. Test for bit errors.
4. Test kilobit rate.
5. Multiply by factor of 8 and convert raw intensity to floating point.
6. Apply intensity factor from table for this element.
7. Read more data from DECOM tape when needed.
8. Print message and skip to next frame when frame count exceeds 32 elements.
9. Test for fill data.
10. Fix up routine for missing data (new line > 22).
11. Print message and skip to next frame when picture exceeds 22 lines.
12. Continue when new line number equals zero.

Programs Used

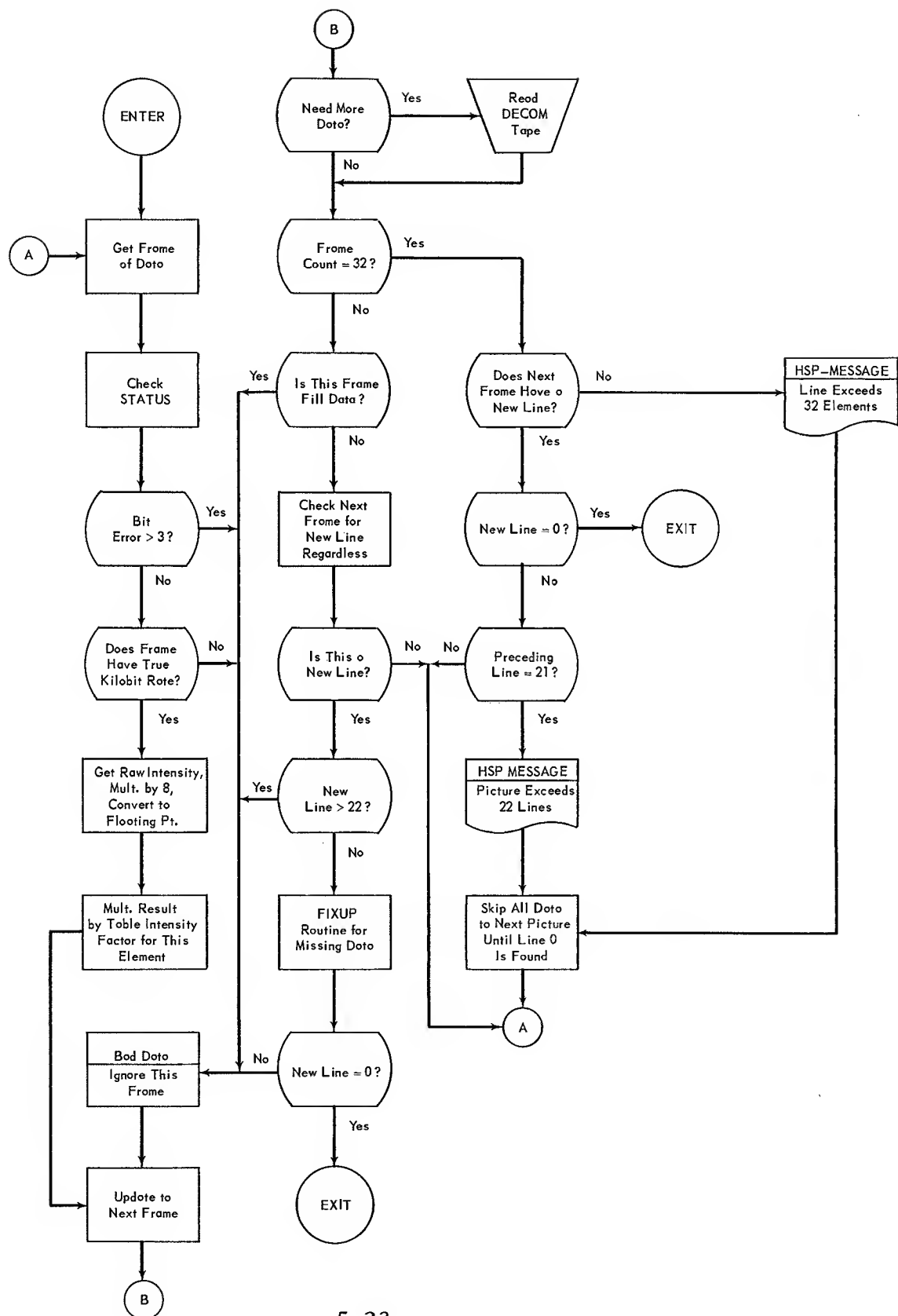
DECDAT

PRINT\$

RESET

TESTD (entry SKPICT)

5-22



TVTAPE (Sleuth II)

Function

Writes TV output tape.

Calling Sequence

In-line code.

Operational Description

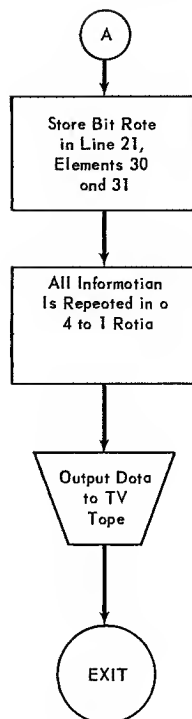
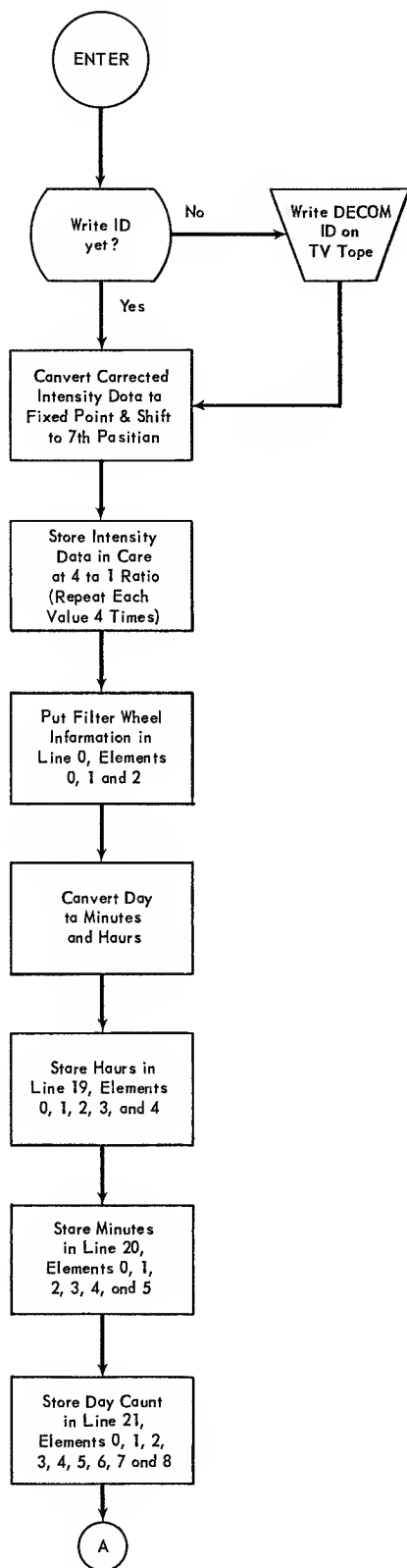
1. Write DECOM identification on TV tape if it has not yet been done.
2. Convert and shift intensity data and store at 4 to 1 ratio.
3. Pick up, convert as necessary and store in proper line/element array:
 - a. Filter wheel information.
 - b. Hours, minutes, day count.
 - c. Bit rate.
4. Repeat all information at 4 to 1 ratio.
5. Write output data on TV tape.
6. Continue.

Programs Used

MV FY1\$
MV FY2\$
TWR\$
KTYPE\$
MERR\$

DATA PROCESSING PROGRAM

TVTAPE Output Routine (TVTAPE)



STARRY (Sleuth II)

Function

Subtracts starry background intensities.

Calling Sequence

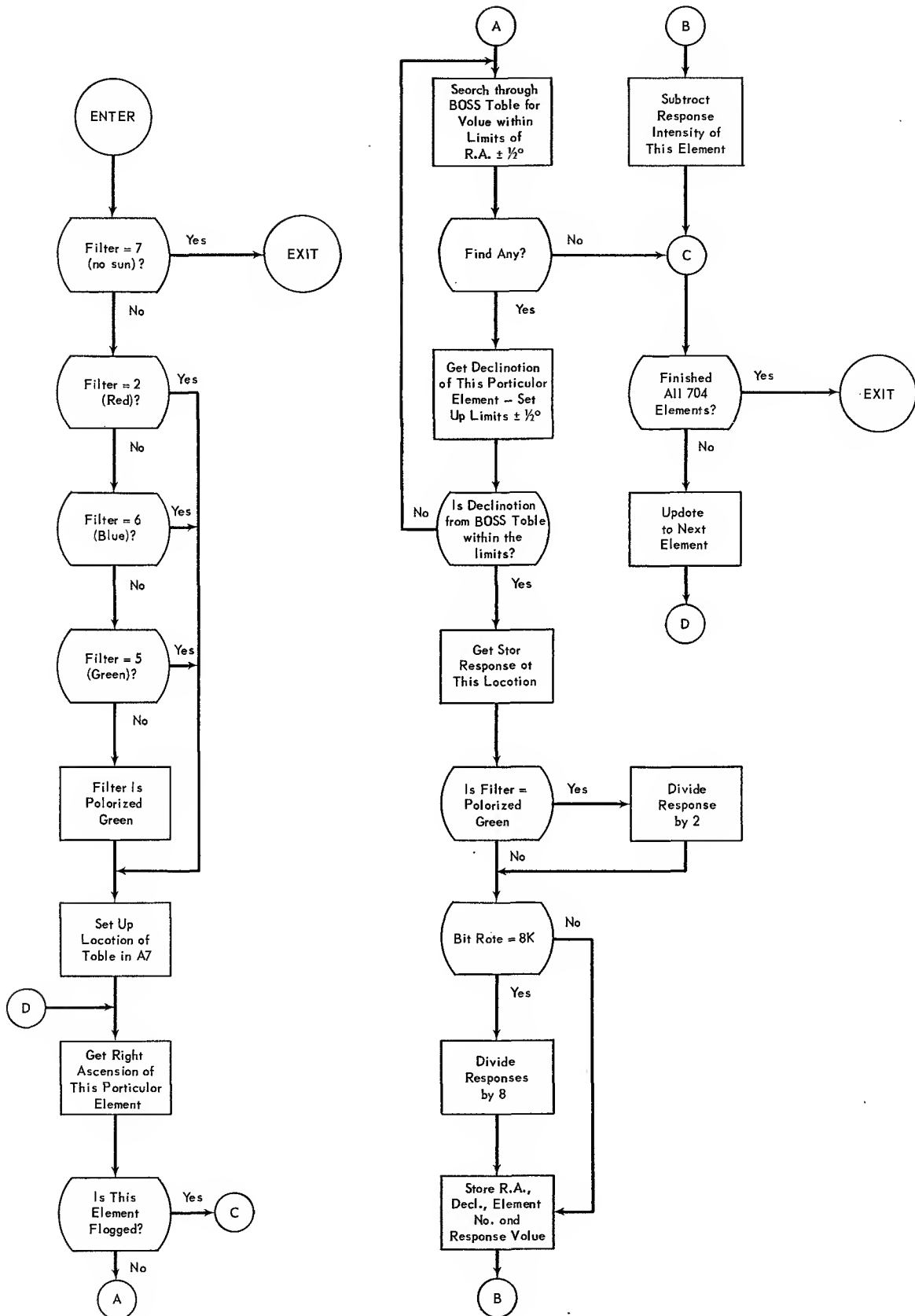
SLJ STARRY

Operational Description

1. Determine filter wheel position.
2. Exit if filter position 7 (no sun).
3. Set up location of table in A7 according to filter wheel position.
4. Get right ascension of element.
5. Increment to next element if this element is flagged.
6. Search BOSS table for a value within $\pm 1/2^\circ$ limit.
7. Increment to next element if no BOSS table entry is found.
8. Pick up declination and set up limits if entry is found.
9. Continue search through BOSS table if declination is not within $\pm 1/2^\circ$ limits.
10. Pick up star response when one is found within range.
11. Divide star response by 2 if polarized green filter is in position.
12. Divide star response by 8 if bit rate is 8K.
13. Store right ascension, declination, element number and response value.
14. Subtract response value from intensity of this element.
15. Increment to next element.
16. Exit when all 704 elements are finished.

Programs Used

None



DECID (Sleuth II)

Function

Reads DECOM identification from tape.

Calling Sequence

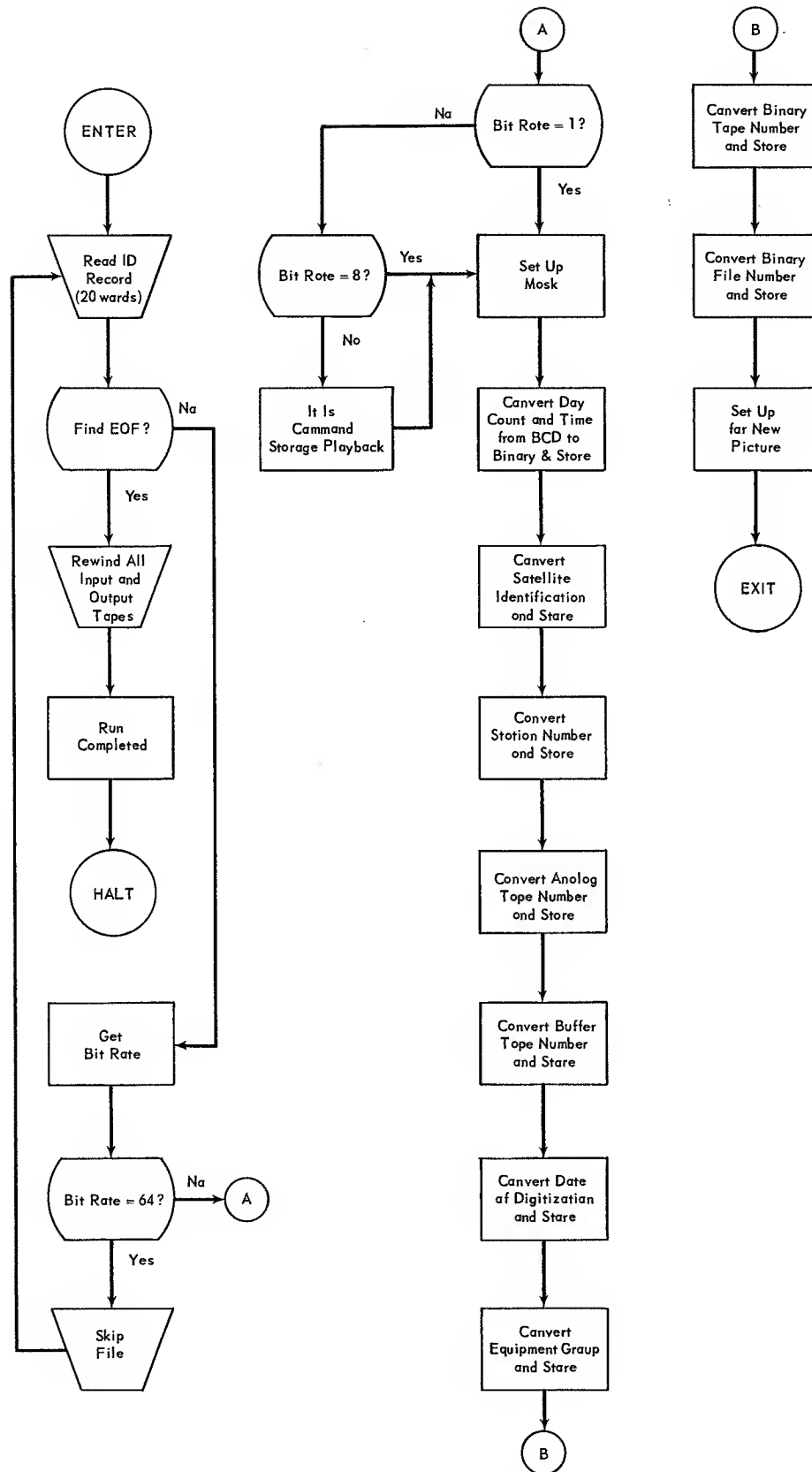
SLJ DECID

Operational Description

1. Read identification record (20 words).
2. Rewind all input/output tapes and halt when EOF is encountered.
3. Skip input file if bit rate is 64.
4. Determine command storage playback if bit rate is not 1 or 8.
5. Convert and store:
 - a. Day count and time.
 - b. Satellite identification.
 - c. Station number.
 - d. Analog tape number.
 - e. Buffer tape number.
 - f. Date of digitization.
 - g. Equipment group.
 - h. Binary tape and file number.
6. Initialize for new picture.
7. Exit.

Programs Used

MVFY1\$	TPE\$	TRI\$
MVFY2\$	KTYPE\$	MEXIT\$
TRF\$	TEF\$	EBCDB\$



DECDAT (Sleuth II)

Function

Reads DECOM data from tape.

Calling Sequence

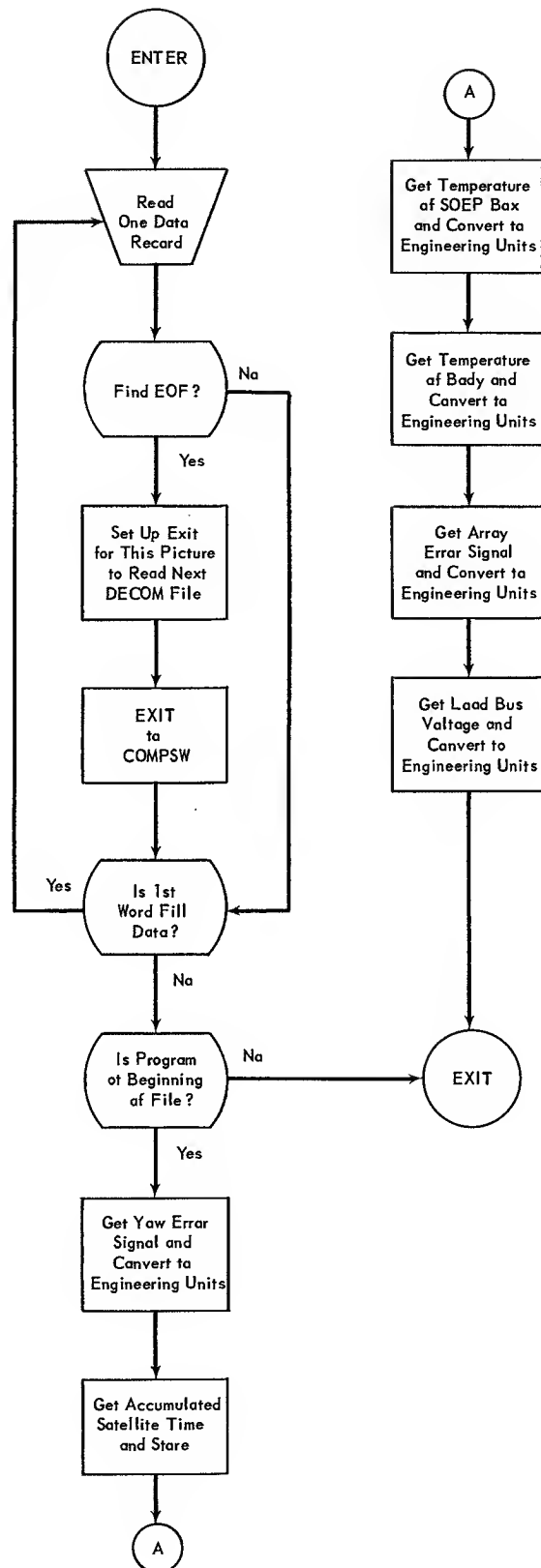
SLJ DECDAT

Operational Description

1. Read one data tape record.
2. Finalize and exit to COMPSW when EOF is encountered.
3. Test for fill data.
4. Exit if not at beginning of file.
5. Convert into engineering units and store:
 - a. Yaw error signal.
 - b. Accumulated satellite time.
 - c. Temperature of SOEP box and body.
 - d. Array error signal.
 - e. Load bus voltage.
6. Exit.

Programs Used

MV FY1\$
MV FY2\$
TRF\$



ASPID (Sleuth II)

Function

Reads attitude identification from tape.

Calling Sequence

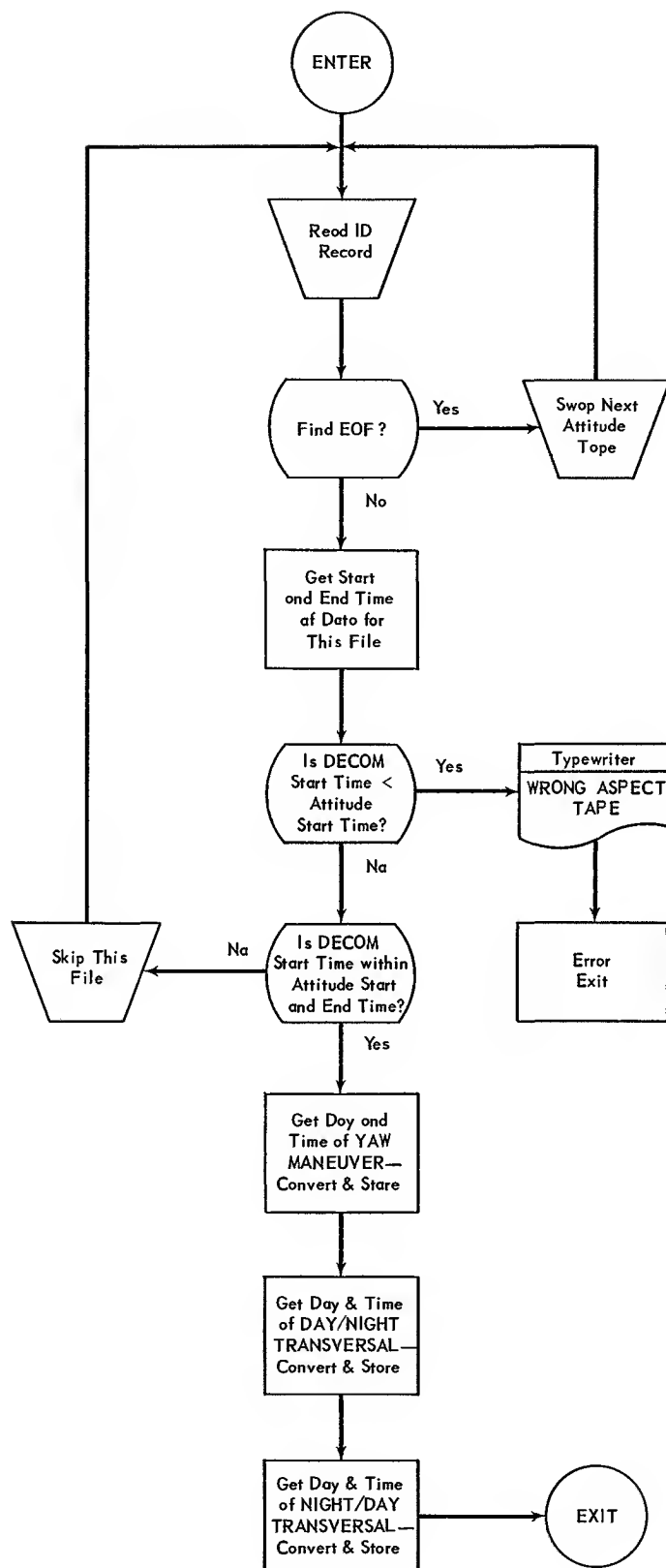
SLJ ASPID

Operational Description

1. Read identification tape record.
2. Swap with next attitude tape when EOF is encountered.
3. Pick up start and end time for this file.
4. Print typewriter message (WRONG ASPECT TAPE) and exit when DECOM start time preceeds attitude start time.
5. Skip this file if DECOM start time follows attitude end time.
6. Convert and store day and time of:
 - a. Yaw maneuver.
 - b. Day - night transversal.
 - c. Night - day transversal.
7. Exit.

Programs Used

MVFY1\$	TPE\$
MVFY2\$	MERR\$
TRF\$	TSWAP\$
FLTFIX	TESTD (entry DYTOMO)
KTYPE\$	(entry HRMNSC)



ASPDAT (Sleuth II)

Function

Reads attitude data from tape.

Calling Sequence

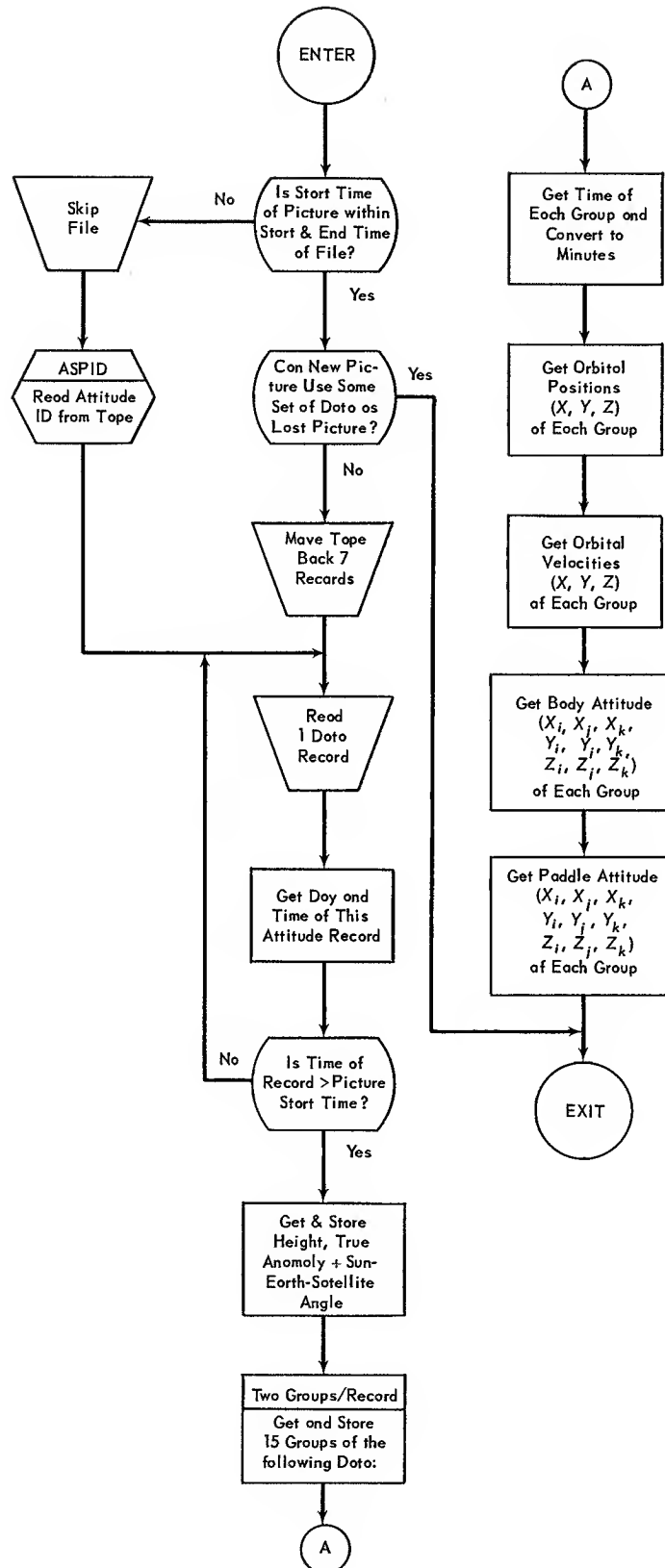
CALL SLJ ASPDAT

Operational Description

1. Skip this file and call ATTITUDE ID READ if start time of picture is not between start and end time of file.
2. Exit if new picture can use same data set as last picture.
3. Back up data tape 7 records, then read forward until match is located.
4. Pick up and store height, true anomaly and sun-earth-satellite angle.
5. Pick up, convert as required and store 15 groups (2 groups per record) of:
 - a. Time (minutes).
 - b. Orbital elements.
 - c. Body attitude.
 - d. Paddle attitude.
6. Exit.

Programs Used

TPB\$	TRF\$
TPE\$	FLTFIX
ASPID	
MV FY1\$	
MV FY2\$	



Function

Least squares quadratic solution. Also solves for angle β , rotates picture, computes RA and DEC for each element, and finally applies corrections if switch 5 is on.

Calling Sequence

LMJ 11, LSQS (21 COMMON names)
NOP 0

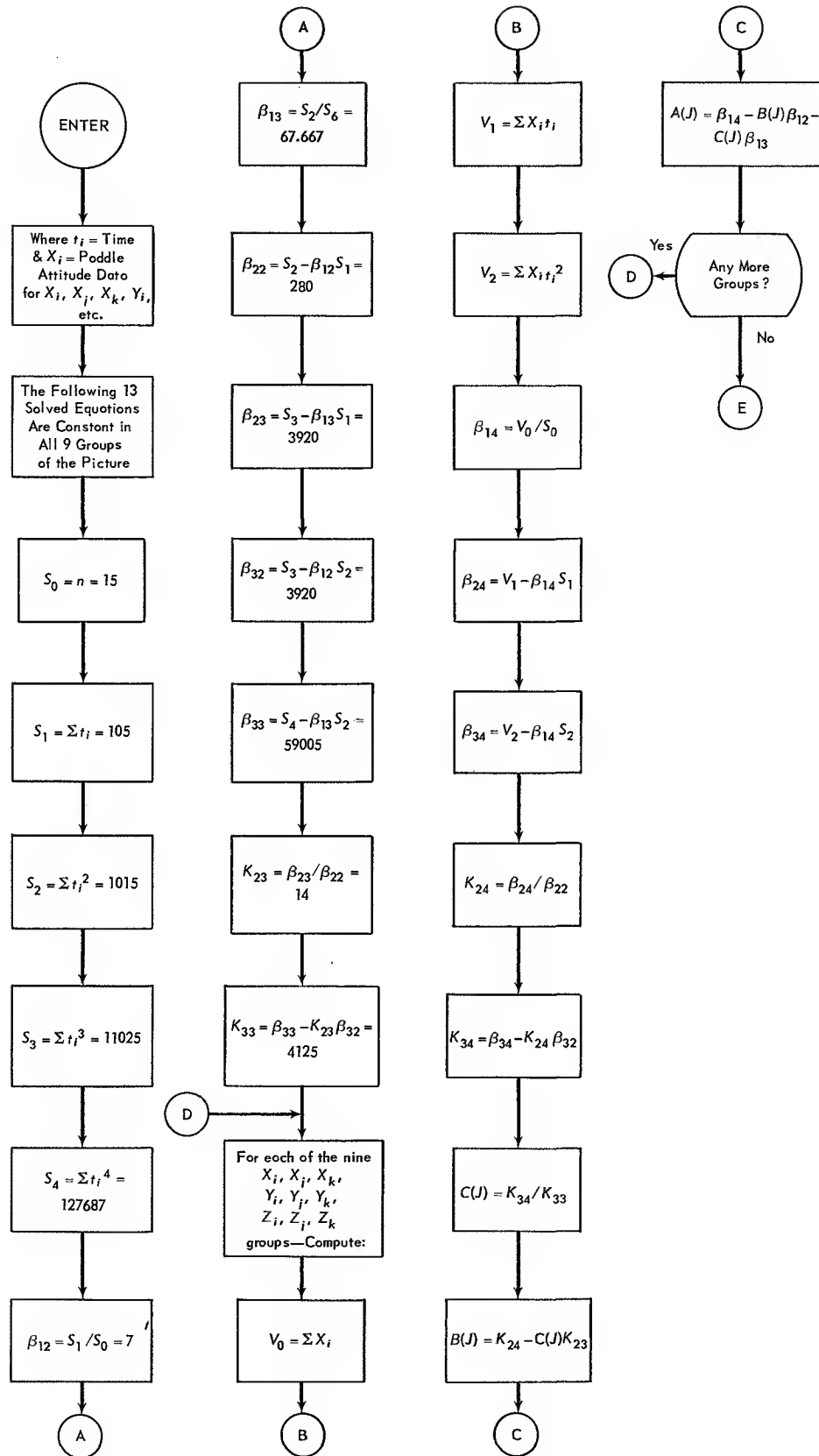
Operational Description

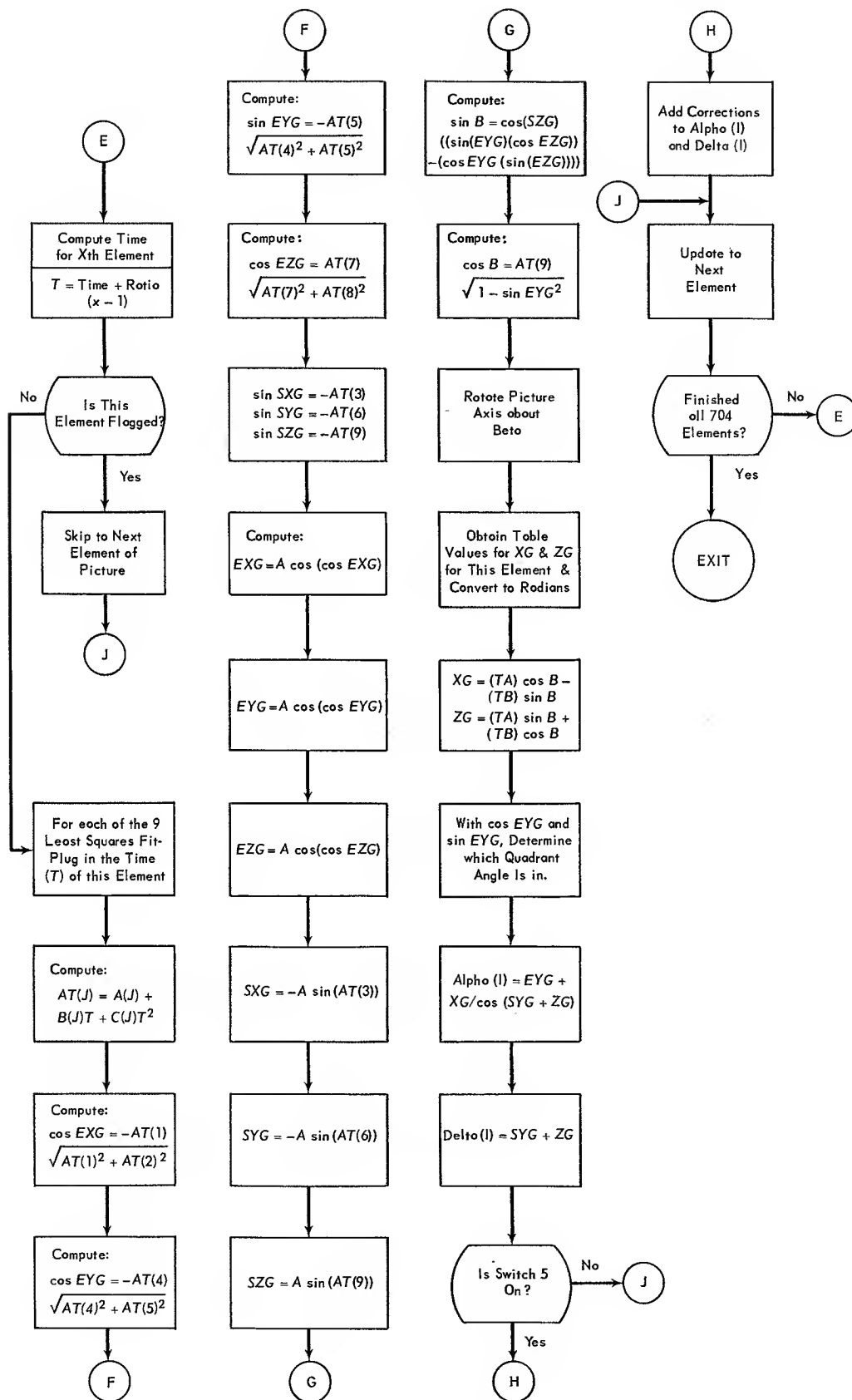
1. Set up 13 solved equations which are constant for all 9 groups of the picture:
 $S_{0-4}, \beta_{12}, \beta_{13}, \beta_{22}, \beta_{23}, \beta_{32}, \beta_{33}, K_{23}, K_{33}$
2. Solve for each of the 9 groups ($X_{i,j,k}, Y_{i,j,k}, Z_{i,j,k}$) the following:
 - a. V_0, V_1, V_2
 - b. $\beta_{14}, \beta_{24}, \beta_{34}$
 - c. K_{24}, K_{34}
 - d. $C(J), B(J), A(J)$
3. Compute time (T) for Xth element.
4. Skip to next picture element if this element is flagged.
5. Plug in time (T) of this element for each of the 9 least-squares-fit.
6. Compute attitude elements.
7. Rotate picture about Beta.
8. Find table values for X_g and Z_g for this element and convert to radians.

9. Determine quadrant.
10. Compute $\alpha(I)$ and $\delta(I)$.
11. Add corrections to $\alpha(I)$ and $\delta(I)$ when switch 5 is on.
12. Increment to next element.
13. Exit when all 704 elements are finished.

Programs Used

SORT	NWDU\$
ACOS	NIO1\$
ASIN	NIO2\$
COS	NSTCH\$





ROTATE (Fortran IV)

Function

Rotates right ascension and declination for every picture element into ecliptic coordinates.

Calling Sequence

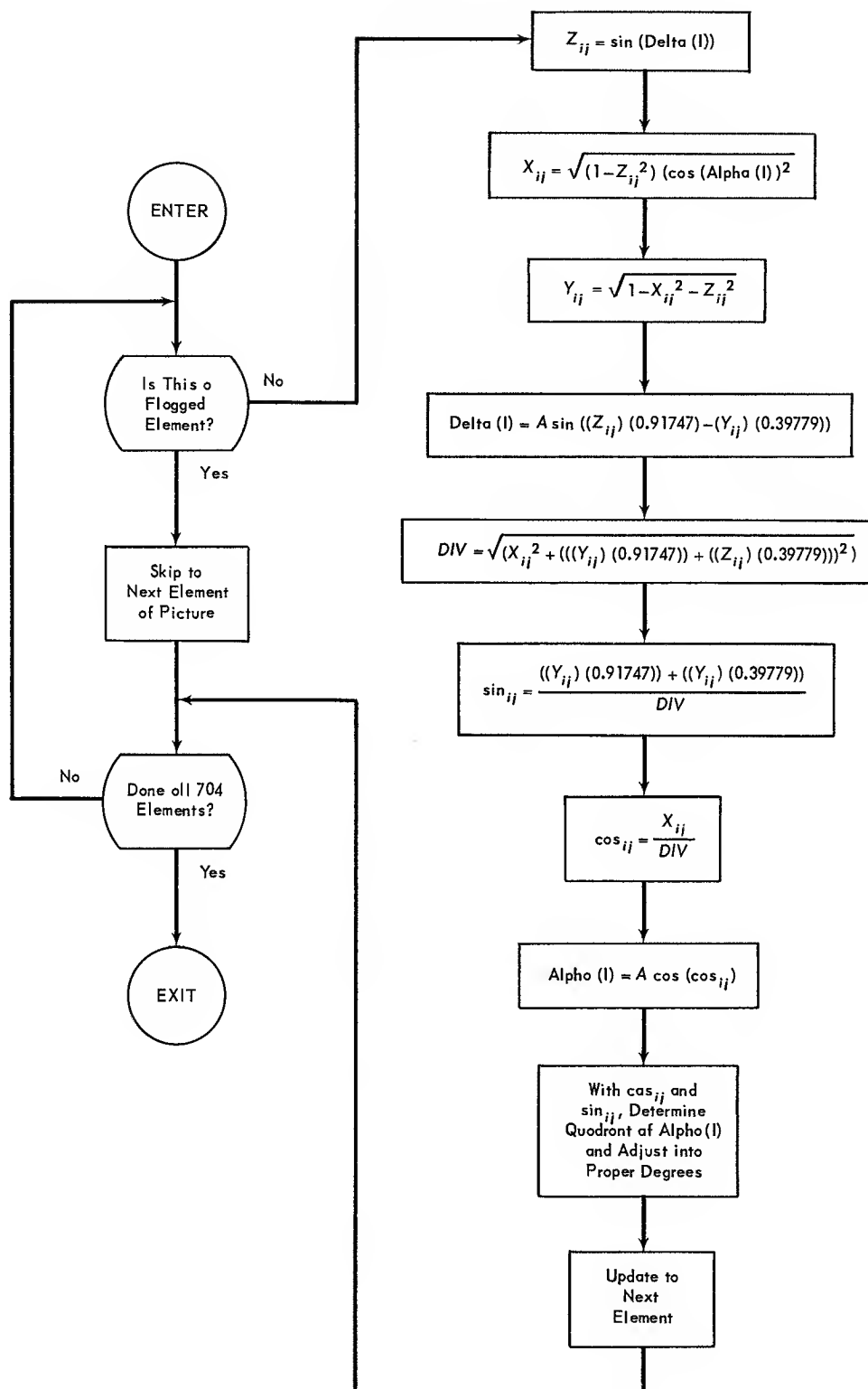
LMJ 11, ROTATE (15 COMMON names)
NOP 0

Operational Description

1. Increment to next element if this element is flagged.
2. Compute X_{ij} , Y_{ij} , Z_{ij} .
3. Compute $\delta(I)$, $\alpha(I)$.
4. Determine quadrant for $\alpha(I)$ and convert into degrees.
5. Exit when all 704 elements are finished.

Programs Used

SIN
SORT
COS
ASIN
ACOS



OUTPUT (Fortran IV)

Function

Writes output on high speed printer and tape.

Calling Sequence

LMJ	OUTPUT	(23 COMMON names)
NOP	0	

Operational Description

1. Write unit 28 (on-line):
 - a. ID record, DECOM identification and filter wheel position.
 - b. Start and end time of picture and eclipse. Time of yaw maneuver and accumulated satellite time.
 - c. Temperature of SOEP box and body package, load bus voltage.
 - d. Yaw error, array error, true anomaly, height and sun-earth-satellite angle.
 - e. Body and paddle attitude.
 - f. Orbital positions and velocities.
 - g. Right ascension, declination, corrected and raw intensity.
2. Write on-line whenever starry background was subtracted:
 - a. Element number, right ascension, and declination.
 - b. Starry background subtracted.
3. Write 5 records on tape 13:
 - a. Record 1 - ID information
 - b. Record 2 - ID and right ascension
 - c. Record 3 - ID and declination

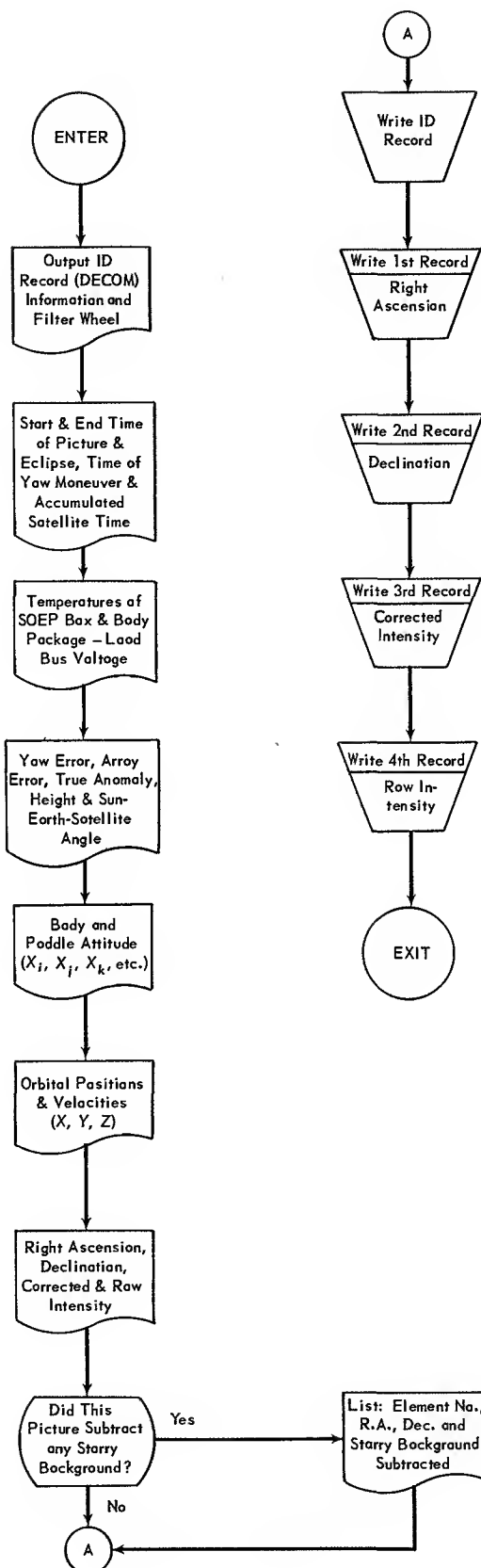
d. Record 4 - ID and corrected intensity

e. Record 5 - ID and raw intensity

4. Exit.

Programs Used

NWDU\$	NIO2\$	NWBT\$
	NIO1\$	NWEF\$



DISPLAY PROGRAM

COMPUTATION PROCEDURE

The Display Program is designed to provide a convenient tool for presenting large volumes of gegenschein experiment data in a time-sequenced motion picture. The program is written in Fortran IV language for the Univac 1107-08 computer and uses the SC 4020 software package developed by Computer Sciences Corporation.

Computation is performed in three separate phases, which are not necessarily three separate machine runs. In the first phase, experiment data is subjected in time sequence to a filtering process where unrecognizable data frames are eliminated. Valid frames are written onto a Photo Tape, which serves as a collection pool for the frame data; approximately 700 frames may be contained by the tape. In addition, cards (Frame Edit Cards) are punched for use in controlling the remaining processing phases.

In the second phase, the data on the Photo Tape is converted SC 4020 instructions for visual presentation. Each resulting picture frame contains, in addition to the grid labels, a frame number, the picture time in days and seconds, the filter number, and the true anomaly value in degrees. During this phase, frames are edited according to specifications entered in program control cards, to compensate for wide ranging intensity levels or picture skewness.

In the third phase, the data generated in the second phase is duplicated on tape for use with the SC 4020 in producing a 35 mm. movie film.

SUBROUTINE DESCRIPTIONS AND FLOWCHARTS

Name	Code	Description
GEGEN	Fortran	Main Program - Display Program
PICTUR	Fortran	Preprocessing for FRAME
FRAME	Fortran	Plots Data with Overlays
GRITE	Fortran	Buffer SC 4020 Output
PLOTV	Sleuth	Plots SC 4020 Characters
LINEAR	Fortran	Linear Interpolation
BSTAT	Fortran	Decode NTRAN Status Flag
MOVE	Fortran	Initiate a read or write of 5 records
GVANCE	Sleuth	Identification for SC 4020
GCLOK	Fortran	Print Elapsed Time
NTAB\$		I/O Channel Allocator

GEGEN (Fortran)

Function

This is the main routine for the Gegenschein Display Program. It functions as a main control in addition to preparing the Photo Tape from one or more gegenschein tapes.

Calling Sequence

None

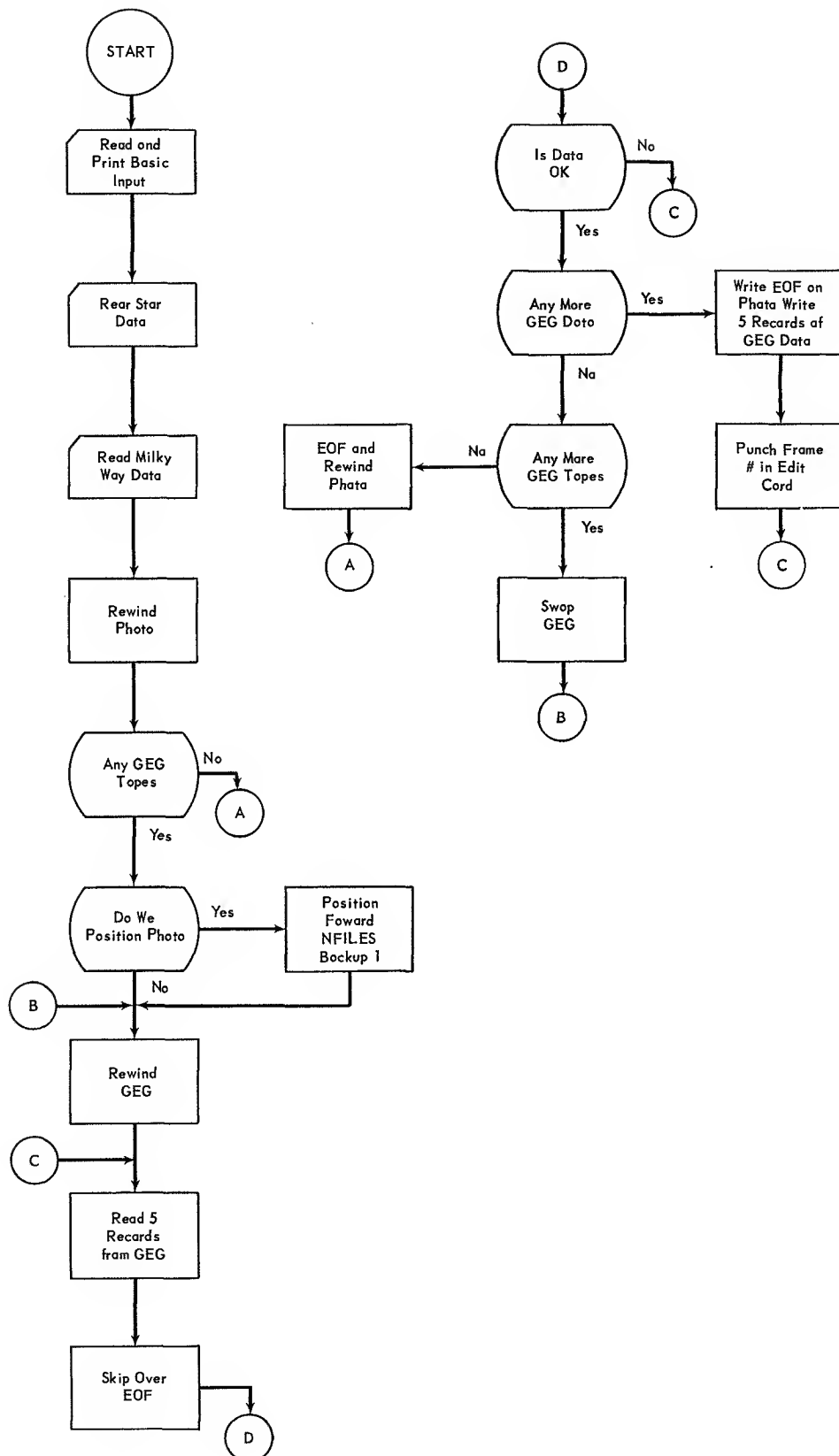
Operational Description

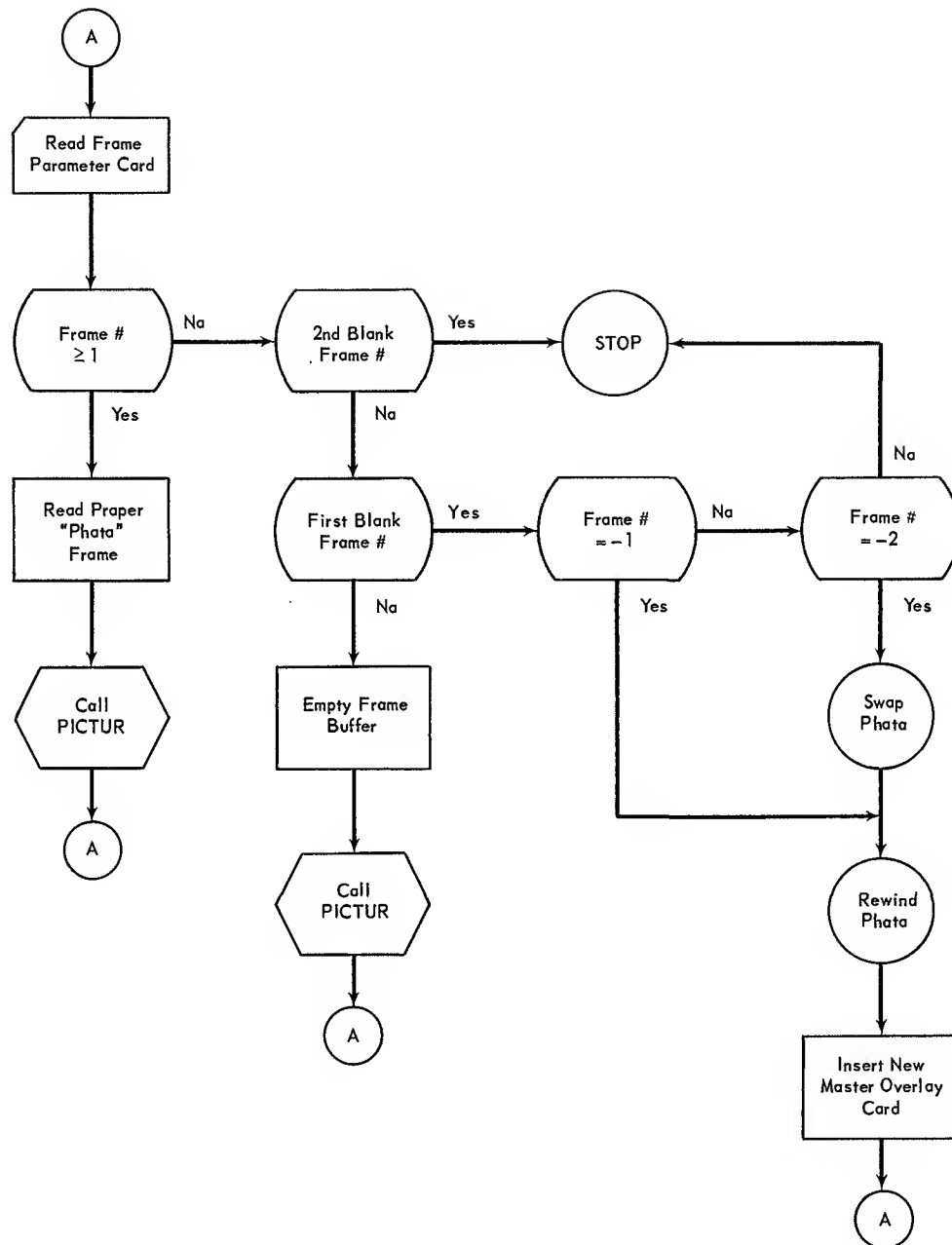
1. Reads and prints six Basic Input Cards.
2. Reads star data, milky way data, and gegenschein tapes (if present).
3. Performs validity check on gegenschein data; buffers out photometry data to the Photo Tape at the designated start point and punches Display Edit Cards containing frame numbers.
4. Reads a Display Edit Card.
5. Buffers in the appropriate photometer frame to an available buffer bank and calls PICTUR.
6. Returns to (4) until no Display Edit Cards remain.
7. STOPS.

Note: Steps 4 and 5 are handled in a flip-flop bufferec fashion.

Programs Used

MOVE
NTRAN
BSTAT
PICTUR
GVANCE
BUFFER
LETTER





PICTUR (Fortran)

Function

Performs preprocessing for FRAME.

Calling Sequence

CALL PICTUR (IBANK)

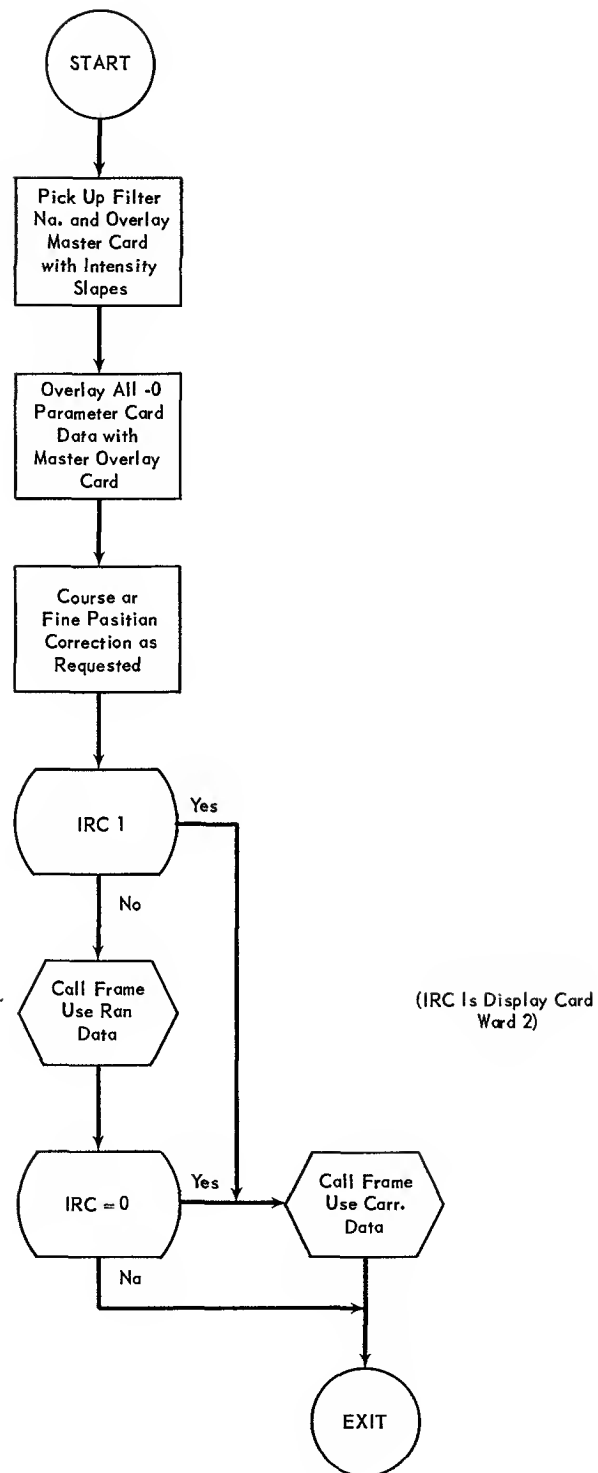
where IBANK is the buffer bank number; all other necessary data is obtained through named common.

Operational Description

1. Merges Display Edit Card data with the Master Overlay Card data.
2. Performs fine or coarse position correction if requested.
3. Makes appropriate call or calls to FRAME.

Programs Used

FRAME



FRAME (Fortran)

Function

Plots gegenschein photometry data with the designated overlays.

Calling Sequence

CALL FRAME (IBANK, IRC)

where IBANK is the Buffer data number: 1 = bank 1
2 = bank 2

IRC is the type data flag: 1 = raw data
2 = corrected data

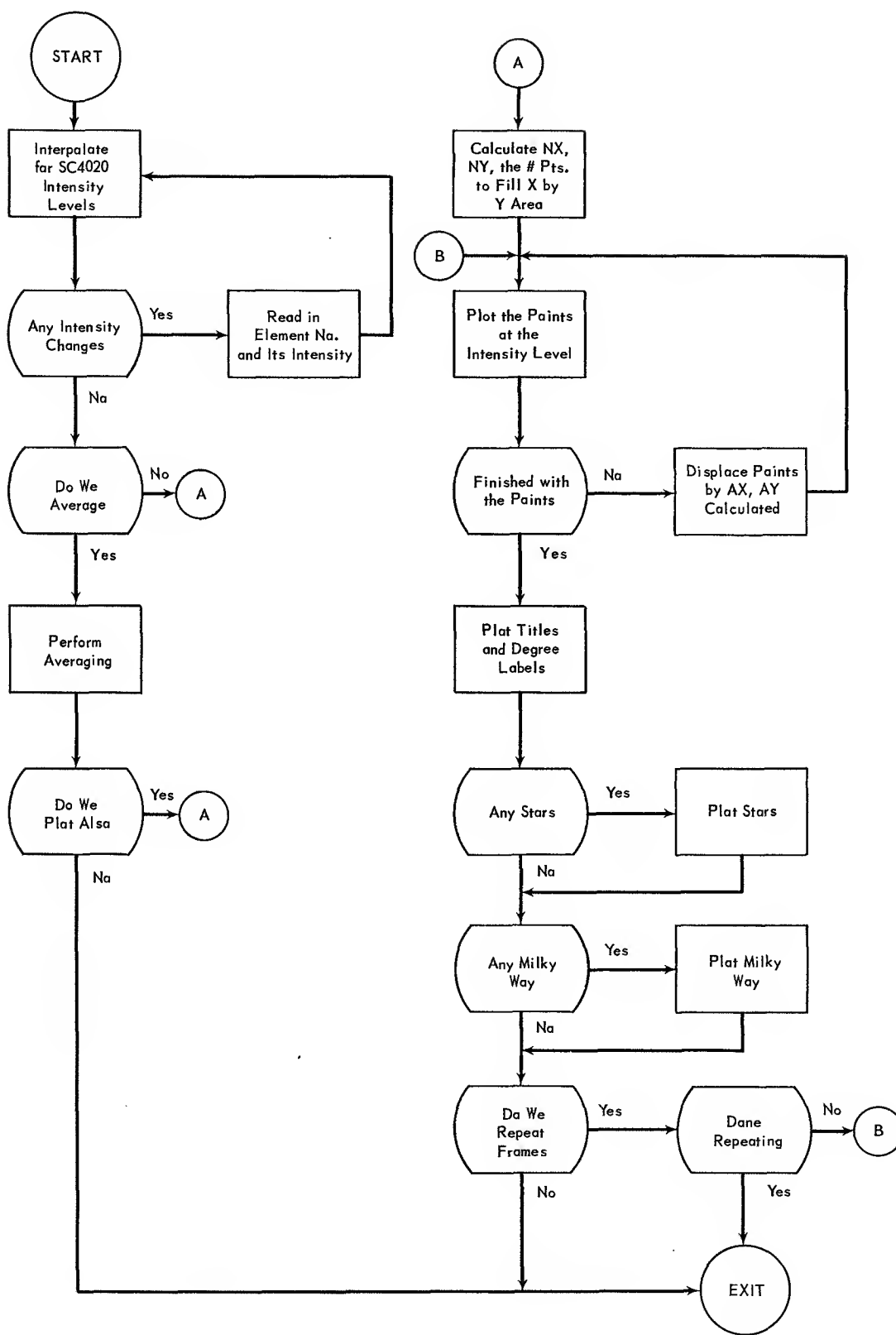
Other necessary data is obtained through named common.

Operational Description

1. Pick up data from correct bank and print elapsed time if indicated.
2. Pick up raw or corrected data intensities.
3. Interpolate intensity data and perform averaging if requested.
4. Read in intensity modifications, if any.
5. Calculate the necessary number and spacing between the plot points which will cover the $X^0 \times Y^0$ area.
6. Plot the points at the designated intensity level.
7. Overlay axis titles, degree markers, frame number, etc.
8. Advance film.
9. Return to (6) if repeat frames are requested; otherwise return.

Programs Used

LINEAR	LETTER	BUFFER
PLOTV	SET	GCLOK
PLOTVL	GVANCE	



GRITE (Fortran)

Function

Buffer SC 4020 instructions to output tape using NTRAN.

Calling Sequence

CALL GRITE (BADD, IS, IC)

where:

BADD is the buffer address defined with a call to BUFFER
(CSC plot package).

IS is buffer size.

IC is "count" the number of words to buffer out.

Operational Description

The single call to GRITE has replaced the tape write sequence of routine RITE in the CSC plot package. The resulting buffered output from GRITE is identical to that produced by RITE and is, therefore, compatible with the SC 4020 hardware. Additional parameters required by GRITE are entered via named common:

LB - an array for NTRAN status flags

LS - the number of variable sized buffers

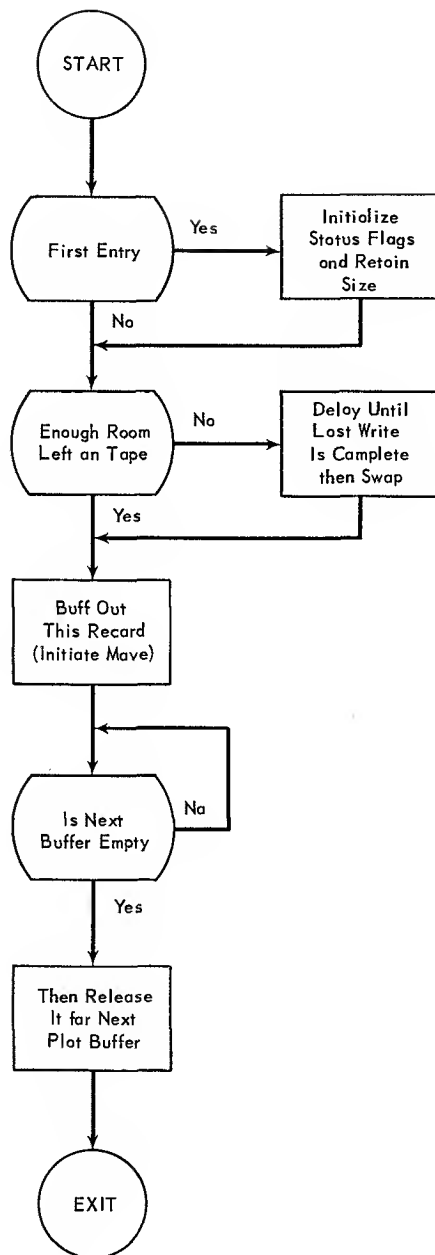
ITOL - the number of words output prior to tape swapping

IPLOT - the output tape unit

While a call to GRITE is never initiated by the user, the buffer may be unloaded by the call to RITE as before.

Programs Used

NTRAN
BSTAT



(Only after Encountering Advance Instruction)

Tape Error Procedure:

1. Release Error Unit
2. Write EOF
3. Rewind with Interlock
4. Swap Next Reel
5. Rewind It

Tape Swap Procedure:

1. Write EOF
2. Rewind with Interlock
3. Swap to Next Reel
4. Rewind It

PLOTV (Sleuth)

Function

Plots an SC 4020 character at a specified intensity level.

Calling Sequence

CALL PLOTV (BUF, N, X, Y, DELX, DELY, IHC, ISCALE, I)

where:

I is the address of the intensity level array.

For detailed discussion on the remaining parameters, consult the Computer Sciences Corporation Users Manual for the UNIVAC 1107 linked SC 4020 microfilm recorder.

Operational Description

An additional entry to the CSC plot package has been incorporated to utilize the specified intensity plot command (OPCODE 01).

Programs Used

PLOTP
BOOK

LINEAR (Fortran)

Function

Linear interpolation.

Calling Sequence

CALL LINEAR (IX, IY, IX0, IY0, IXI, IYI, INUM)

where:

IX is the input array.

IY is the resulting output after interpolating.

INUM is the array length.

Operational Description

This routine is used for intensity interpolation where the Y values relate to SC 4020 intensities and the X values to data intensities as,

$$A = (IYI - IY0) / (IXI - IX0).$$

Then for each IX,

$$IY = IY0 + A (IX - IX0)$$

BSTAT (Fortran)

Function

From the NTRAN status flag, determine the appropriate transfer.

Calling Sequence

CALL BSTAT (J, \$SN1, \$SN2, \$SN3, \$SN4, \$SN5)

where:

J is the status flag to be tested

SN_i are statement numbers to which a transfer is made as follows:

SN1 if $J \geq 0$

SN2 if $J = -1$

SN3 if $J = -2$

SN4 if $J = -3$

SN5 if $J = -4$

(STOP is executed if none of the above conditions exist).

Programs Used

NONE

MOVE (Fortran)

Function

Initiate a read or write of five records.

Calling Sequence

CALL MOVE (D1, D2, D3, D4, D5, IS, ITAPE, IDIR)

where:

D1 - D5 are data record addresses whose length is fixed at
compile time.

IS is an array for the status flags.

ITAPE is the tape number to or from which data is moved.

IDIR is the movement direction: 1 = buffered write
 2 = buffered read

Operational Description

This special-purpose routine was written to buffer gegenschein data in and out.

Programs Used

NTRAN

GVANCE (Sleuth)

Function

Adds an identification integer to the SC 4020 advance instruction prior to its insertion in the plot output buffer.

Calling Sequence

CALL GVANCE (BUF, N)

where:

BUF is the buffer address (see routine VANCE).

N is the integer to be added.

Programs Used

VANCE

GCLOCK (Fortran)

Function

Prints elapsed time in seconds between calls.

Calling Sequence

CALL GCLOCK (I, J)

where:

I is current time in seconds obtained in subroutine GCLOCK from a call to GCL (Sleuth).

J is the execution flag; designated > 0 for execution.

Programs Used

GCL

NTAB\$

Function

Channel allocator as:

```

      +3
      +2
      +1
NTAB$* +'A'
      +'B'
      +'C'
      +'D'
      +'E'
      +'F'
      END
```

Note: Various routines were modified to remove plot constraint of (120 - 127).
A small additional change will complete the plot tape variability.

FILTER RESPONSE PROGRAM

The Filter Response Program was created to compute the theoretical response of the gegenschein photometer to various star types for each of the colored filters. The program is not a part of the Gegenschein Analysis System (i. e., the production system). The results of the program were used, after manual interpolation, to create the Star Table Tape used by the Gegenschein Processing Program.

COMPUTATIONAL PROCEDURE

The program evaluates the following integral,

$$\int_{\lambda_1}^{\lambda_n} I(\lambda) t(\lambda) \delta(\lambda)$$

where:

$$I(\lambda) = \frac{x^5 e^{-x}}{21.201}$$

$$x = \frac{1.43868 \times 10^4}{\lambda T}$$

λ = wave length of the filter as follows:

Filter 1: 0.224u to 0.356u

Filter 2: 0.400u to 0.640u

Filter 3: 0.650u to 0.850u

T = temperature to be used for each filter as follows
(the type of star is directly proportional to its temperature):

(1) 70000 ^o K	(9) 13000	(17) 5400
(2) 60000	(10) 11000	(18) 4800
(3) 50000	(11) 9000	(19) 4200
(4) 40000	(12) 8200	(20) 3800
(5) 38000	(13) 7400	(21) 3200
(6) 30000	(14) 6700	(22) 2800
(7) 22000	(15) 6300	(23) 2400
(8) 15400	(16) 5800	(24) 2000

t = value of $t_i(\lambda)$ for the filter.

The program loops through three sets of λ 's (one for each filter) and evaluates each set for all 24 temperatures (T). For each filter, the integral is evaluated in increments of .004 between the limits of λ .

The program produces a printout of the computed integral for each temperature (T) for each filter (Figures 5-7, 5-8, and 5-9) and a table of color temperatures by spectral type (Figure 5-10). The Boss General Catalogue of Stars, which is contained on a set of magnetic tapes, was then input to another program along with the evaluations of the integral for the various spectral types of stars. This program remade the Boss Catalogue into a catalogue of stars as the photometer would see them by applying the following equation to each star:

$$R = a \cdot T_c \cdot 10^{-2/5m} \cdot I_f(T_c)$$

where: R = photometer response in counts/picture element.

m = apparent visual magnitude in Boss Catalogue.

T_c = color temperature of star.

a = constant chosen such that a star of visual magnitude +5 and spectral type G0 gives a response in the green filter of 4400 counts/picture element at the 1Kb rate.

$I_f(T_c)$ = value of integral (for each filter).

Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)
05	.00000012	A5	.00026529	G5	.00130636
06	.00000024	A6	.00032592	G6	.00133940
07	.00000045	A7	.00035883	G7	.00137244
08	.00000080	A8	.00041368	G8	.00140549
09	.00000142	A9	.00044659	G9	.00143553
B0	.00000205	F0	.00049052	K0	.00149561
B1	.00000393	F1	.00055876	K1	.00155569
B2	.00000534	F2	.00060994	K2	.00160387
B3	.00000969	F3	.00064881	K3	.00164011
B4	.00001554	F4	.00071433	K4	.00165823
B5	.00001944	F5	.00077985	K5	.00167635
B6	.00003105	F6	.00082854	K6	.00169447
B7	.00004560	F7	.00088224	K7	.00169102
B8	.00006015	F8	.00093594	K8	.00168757
B9	.00007470	F9	.00098964	K9	.00168541
A0	.00008841	G0	.00105036	M0	.00165001
A1	.00012086	G1	.00111108	M1	.00159691
A2	.00014446	G2	.00117598	M2	.00154381
A3	.00017919	G3	.00120843	M3	.00150841
A4	.00022511	G4	.00124088	M4	.00143500
				M5	.00132160

Figure 5-7. Table of Integral (IF (Tc)) for Various Spectral Type (ST) Red Filter

Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)
05	.00002724	A5	.00559784	G5	.00229577
06	.00004955	A6	.00561868	G6	.00215419
07	.00008613	A7	.00561077	G7	.00201261
08	.00013837	A8	.00559747	G8	.00187102
09	.00022687	A9	.00558949	G9	.00174251
B0	.00030949	F0	.00557885	K0	.00148549
B1	.00033403	F1	.00537829	K1	.00122847
B2	.00065308	F2	.00522785	K2	.00100233
B3	.00097016	F3	.00509288	K3	.00080705
B4	.00137216	F4	.00483843	K4	.00070941
B5	.00164012	F5	.00458396	K5	.00061177
B6	.00209619	F6	.00438285	K6	.00051415
B7	.00257930	F7	.00415027	K7	.00041785
B8	.00306240	F8	.00391769	K8	.00032155
B9	.00354551	F9	.00368511	K9	.00025720
A0	.00394351	G0	.00341642	M0	.00022420
A1	.00442489	G1	.00314773	M1	.00017470
A2	.00477495	G2	.00286357	M2	.00012520
A3	.00508631	G3	.00272149	M3	.00009220
A4	.00535911	G4	.00257941	M4	.00005373
				M5	.00003693

Figure 5-8. Table of Integral (IF (Tc)) for
Various Spectral Types (ST)
Blue Filter

Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)
05	.00000115	A5	.00134544	G5	.00335166
06	.00000221	A6	.00155464	G6	.00334894
07	.00000409	A7	.00166552	G7	.00334622
08	.00000701	A8	.00185032	G8	.00334350
09	.00001222	A9	.00196120	G9	.00330886
B0	.00001738	F0	.00210899	K0	.00323950
B1	.00003190	F1	.00229047	K1	.00317030
B2	.00004279	F2	.00242658	K2	.00305341
B3	.00007363	F3	.00251850	K3	.00288887
B4	.00011443	F4	.00265827	K4	.00280660
B5	.00014163	F5	.00279804	K5	.00272433
B6	.00021222	F6	.00288639	K6	.00264205
B7	.00029772	F7	.00296989	K7	.00245800
B8	.00038322	F8	.00305339	K8	.00227395
B9	.00046872	F9	.00313689	K9	.00215143
A0	.00054625	G0	.00320097	M0	.00200423
A1	.00070729	G1	.00326505	M1	.00178343
A2	.00082441	G2	.00330079	M2	.00156263
A3	.00098034	G3	.00331866	M3	.00141543
A4	.00117506	G4	.00333653	M4	.00119774
				M5	.00098684

Figure 5-9. Table of Integral (IF (Tc)) for Various Spectral Types (ST) Green Filter

Spectral Type (ST)	Color Temperature (TC)	Spectral Type (ST)	Color Temperature (TC)	Spectral Type (ST)	Color Temperature (TC)
05	70,000	A5	11,100	G5	5,700
06	61,000	A6	10,500	G6	5,600
07	54,000	A7	10,200	G7	5,500
08	48,000	A8	9,700	G8	5,400
09	42,000	A9	9,400	G9	5,300
B0	38,000	F0	9,000	K0	5,100
B1	34,000	F1	8,600	K1	4,900
B2	31,000	F2	8,300	K2	4,700
B3	28,000	F3	8,100	K3	4,500
B4	25,000	F4	7,800	K4	4,400
B5	23,000	F5	7,500	K5	4,300
B6	21,000	F6	7,300	K6	4,200
B7	19,500	F7	7,100	K7	4,050
B8	18,000	F8	6,900	K8	3,900
B9	16,500	F9	6,700	K9	3,800
A0	15,300	G0	6,500	M0	3,700
A1	14,200	G1	6,300	M1	3,550
A2	13,400	G2	6,100	M2	3,400
A3	12,600	G3	6,000	M3	3,300
A4	11,800	G4	5,900	M4	3,150
				M5	3,000

Figure 5-10. Table of Color Temperatures
by Spectral Type

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